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ORIGINAL ARTICLES

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PLATE I.

The late JAMES MOLLISON, C.S.I., LL.D., M.R.A.C.

ORIGINAL ARTICLES

THE LATE JAMES MOLLISON, C.S.I., LL.D., M.R.A.C.

AN APPRECIATION.

DR. JAMES MOLLISON, C.S.I., whose death is announced by Reuter, was educated at the Royal Agricultural College, Cirencester. After some practical experience of farming both in Canada and in England, he was appointed Superintendent of Farms, Bombay, in 1890. In 1897, his designation was changed to that of Deputy Director of Agriculture. When in 1901 the Government of Lord Curzon decided to create the post of Inspector General of Agriculture in India, with a view to co-ordinating the activities of the various Provincial Departments of Agriculture and promoting efficiency, their choice for the first incumbent of the post fell on Dr. Mollison who had done excellent work in Bombay. He held this post until the time of his retirement except for two periods, November 1904 - February 1907 and May 1910 - April 1912, when he was on furlough. On his retirement in 1912 the post of the Inspector General of Agriculture was amalgamated with that of the Director of the Agricultural Research Institute, Pusa; his successor was designated Agricultural Adviser to the Government of India.

Dr. Mollison was made a Companion of the Star of India in 1911, and the honorary degree of LL.D. was conferred on him by the University of Edinburgh in 1922.

The establishment of the Pusa Institute, the reorganization of the Provincial Departments of Agriculture, the constitution of the Board of Agriculture in India, and the recruitment of the first batch of officers to the Indian Agricultural Service were the epoch-making developments during Dr. Mollison's tenure of office at the head of the department. In developing agriculture on scientific lines no man in this country has played a greater part than he.

His "Text-book on Indian Agriculture" in three volumes, though depicting mainly the conditions in the Bombay Presidency as they existed nearly three decades ago, is a classic of its kind.

Reared in the north of Scotland, Dr. Mollison had many of the outstanding qualities which are characteristic of his race. His pawky humour and practical turn of mind were typically Scotch. Upright in all his actions and generous in his estimate of other people, Dr. Mollison's name is still revered in this country both by Indians and Europeans. [D. C.]

DR. HAROLD H. MANN.

AN APPRECIATION.

ON October 16th, 1927, Dr. Harold H. Mann, having reached the age of fifty-five, retired from Government service. By his departure the Department of Agriculture in India sustains a considerable loss. Dr. Mann studied in the Victoria University of Manchester and obtained the B.Sc. degree in 1892 with first-class honours in chemistry, and won the Leblanc Medal of the University for technological chemistry. In the same year he was awarded an "1851 Exhibition Scholarship" for research, and after working some time at Leeds, he went to the Pasteur Institute, Paris, in 1893-94. There he worked specially under Duclaux and felt the inspiration of Pasteur himself. His investigations in the Pasteur Institute were concerned with the action of certain antiseptics on yeast, and the results of this work were published in the *Annales de l'Institut Pasteur* in 1894. After returning to England, he spent some time on research in organic chemistry along with the late Dr. Harry Ingle. He then joined the Royal Agricultural Society, as Chemical Assistant for research, under Dr. J. A. Voelcker, and organized the laboratory and pot culture station at Woburn in 1898. In the same year he obtained the degree of M.Sc.

In April 1900 Dr. Mann came to India as the first Scientific Officer of the Indian Tea Association. Then followed seven years of the most strenuous work. The budget of the Scientific Department of the Tea Association was at first only Rs. 27,000 per annum, and Dr. Mann was supplied with a working bench in the Indian Museum, Calcutta. Beyond that he had no laboratory or assistants. He was chemist, botanist, entomologist, agriculturist and clerk in one. To some present-day workers who feel that no work can be done until they are provided with a palatial laboratory, elaborate apparatus and one or more subordinates, the work turned out by Dr. Mann as a solitary scientist is an example and rebuke. From 1901 to 1907 he published, mostly over his own name and in other cases in association with different workers, twenty-three scientific publications which are still of the first importance to the tea industry. In addition, during this period he also published several other books, papers and memoirs of high scientific value, of which the most important is *The Pests and Blights of the Tea Plant,* which was published in 1903 in collaboration with Sir G. Watt. The work on the tea plantations was done in collaboration with planters, and when it was necessary to do laboratory work on the spot, Dr. Mann carried the needed apparatus and set it up in a corner of a tea factory. The development of the Scientific Department of the Indian Tea Association is worth following. In 1904 the budget was raised to between Rs. 40,000 and Rs. 50,000 and the staff increased by the addition of a second chemist (Mr. C. M.

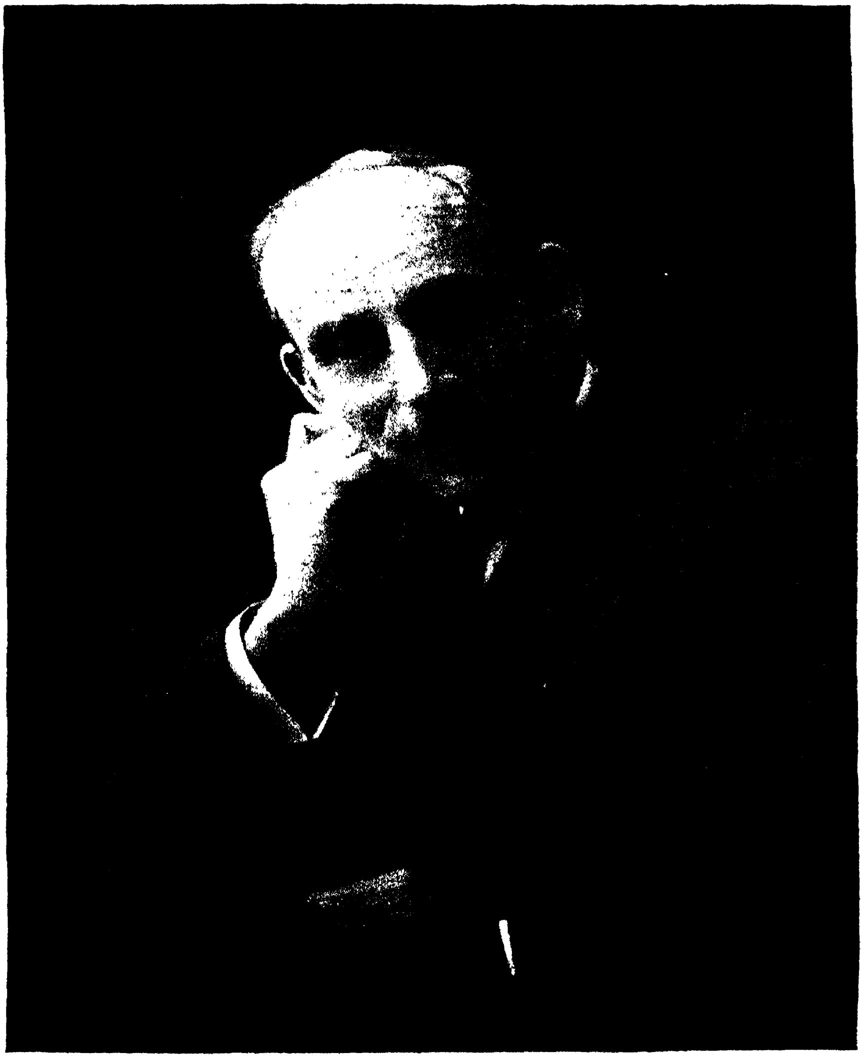

Photo by Elliot and Fry.

DR HAROLD H. MANN.

Hutchinson). An experimental station for the study of tea in Assam was established by Dr. Mann. Later, an entomologist was appointed, and gradually the Scientific Department of the Tea Association has expanded until it has perhaps the best equipped organization in India for the study of the problems of an agricultural industry. On account of Dr. Mann's various important publications on tea and particularly on account of his work on the enzymes of the tea leaf and the fermentation of tea during manufacture, the University of Leeds in 1905 awarded Dr. Mann the degree of D.Sc.

In 1907, Dr. Mann, having left his mark broad and deep on the eastern side of India, came to the western side to do likewise. The Bombay Government was then on the look-out for a Principal for its newly established College of Agriculture at Poona, and came to the conclusion that Dr. Mann was the ideal person for the appointment. He was appointed, in addition, Agricultural Chemist to the Government of Bombay. For the next fourteen years he devoted himself heart and soul to the college whose traditions he firmly established. Of these traditions we may mention particularly the placing of teaching before everything else, the insistence on research by all staff, the development of a research atmosphere, the accessibility of the Principal to students and staff at all times, the spirit of service inspiring staff and students and the spirit of goodwill between all members of a cosmopolitan college. The careers of its graduates, the continued increase in the numbers of applications for admission, and the high standard of work turned out by its research laboratories indicate how well the work of organizing this institution was done.

In 1921, Dr. Mann became Director of Agriculture, the first occasion on which this appointment in the Bombay Presidency had been given to any man outside the I.C.S. What he had done at the college he repeated on a greater scale in the department. The effect of his professional knowledge is nowhere more clearly seen than in the acceleration and amplification of the research activities of the department. This is particularly evident in the line of plant-breeding where staff has been multiplied and results have been obtained in several crops within a comparatively short space of time. During his period of office the department expanded again and again with a corresponding increase of responsibility and work for the head of that department. During the last two years he organized the new research station at Sakrand in Sind whose purpose is to solve problems associated with the advent of irrigation water from the Sukkur Barrage. Despite these many and heavy duties, Dr. Mann found time for a great many other activities. He was a prominent member of the Bombay University and served on its Senate, its Syndicate and numerous minor bodies. In the Senate he always commanded a respectful hearing, and in committee work had a valuable and rare faculty of drafting the formula or resolution which would embody the results of what might have seemed a complicated and contradictory discussion. His recreations took the form of sociological study and social service. His studies of Deccan villages are well known. His social service has taken many forms. He has been associated

with the Y. M. C. A., the I. O. G. T., the Society for the Prevention of Cruelty to Children, and many other similar bodies. He was for a time a member of the Poona Municipality. For the depressed classes he had a particularly soft corner in his heart. In the villages of the Bombay Deccan he was well known and the cultivators regarded him as a real friend.

The above is a long recital but neither complete nor adequate. The writer, whose personal friendship with Dr. Mann dates from 1908 and who has been associated with him in many capacities, is well aware that the members of the Department of Agriculture in India will fill in from their own personal experience many of the gaps that must necessarily be left in so condensed a history. To Dr. Mann this retirement, it is certain, does not mean the cessation of work, and we wish him success in any new sphere which his galvanic personality chooses to invade. [W. B.]

TEA IN NORTH-EAST INDIA.

BY

P. H. CARPENTER, F.I.C., F.C.S.,
Chief Scientific Officer, Indian Tea Association.

HISTORICAL.

TEA is prepared from the young leaves of the tea plant, *Camellia theifera* (Griff.) Dyer. Linnæus first published in 1737 the name of the genus as both *Camellia* and *Thea*, knowing at that time only two species, *japoneca* and *sasanqua*, of the former genus and the tea plant as the sole representative of the latter. As more related species became known, botanists of the nineteenth century gradually became convinced that the difference between the genera was so small that their separation was no longer useful. The united genus is known as *Camellia*.

Linnæus, in his *Species Plantarum*, 1762, distinguished between two varieties of tea, *Thea viridis*, giving rise to the green tea of commerce, and *T. bohea*, giving the black tea. With this distinction, the original name, *Thea senensis*, was dropped. It was later shown that, whether tea was black or green, depended on the manufacture and not on the plant and that both could be made from the same leaf.

Sir George Watt, who made the first detailed study of the botany of the tea plant, considered two main varieties to exist, *viz.*, *viridis* (large-leaved) and *lasiocalyx* (small-leaved). From these two, the other varieties were thought to be derived by hybridization. Later workers have contested this conclusion.

Dr. Cohen Stuart considers that there exists at least two morphological groups of tea plants, one of which is indigenous to India and one to China, while there is no evidence supporting the old idea of any direct genetical or genealogical affinity connecting them. Later, the same botanist distinguished four groups as follows :—

(1) The China group, small-leaved (1½ to 2¾ inches long) found in East and South-east China and Japan.

(2) The group, variety *macrophylla v. siebold*, leaves up to about 5½ inches long, found in Hupeh, Syechuan, Yunnan.

(3) The Shan group, leaves up to 7 inches long, light coloured. Bushes 16-32 feet high, found in Tonkin, Laos, Upper Siam, Upper Burma (Shan States) and perhaps also Assam.

(4) The Manipur group, leaves 8-12 inches long, dark coloured. Bushes 60 feet high, found in Manipur, Cachar, Lushai.

First mention of tea in India is made in 1780 when a few shrubs imported from Canton were planted in Calcutta. In 1788, Sir Joseph Banks studied the problem

and suggested Bihar and Cooch Behar as suitable areas for tea culture. At this time Assam was not included in the British Empire. Although the East India Company were thus acquainted with the fact that tea could be grown in India, no advance was made until 1833 when the monopoly of the China tea trade was lost. In the following year a committee went into the matter and an experimental station was started on the slopes of the Himalayas at Kumaon. The seeds were imported from China and the methods of that country were generally adopted.

Soon after these experiments had been started, information came through that the tea plant had been discovered growing luxuriantly in the jungles of Upper Assam, at that time a country off the beaten track. The honour of this discovery is usually attributed to R. Bruce who saw the plant growing wild on some hills near Rungpore (Sibsagar), then the capital of Assam, which he visited in 1823 to prosecute certain botanical researches, amongst other matters. At the same time he had made an arrangement with one of the Singphos chiefs for a supply of tea plants. Another story attributes the discovery to an Assamese named Moniram Dewan.

At this time Assam was included in the Burmese dominions, and in 1824 the Burmese war broke out and C. A. Bruce, brother of R. Bruce, was ordered to Sadiya in charge of a division of gunboats. On the capture of Rungpore, C. A. Bruce interviewed the Singphos chief who supplied him with tea bushes and seeds which were mostly planted in his (Bruce's) garden at Sadiya. The leaf of these plants was sent to the Botanical Gardens in Calcutta, but whilst it was pronounced to belong to the *Camellia* family and was thought to be a veritable tea plant, it was considered improbable that the Assam species would yield the tea of commerce.

So the matter was dropped until 1833 when C. Bruce again took up the question with such vigour that a committee was appointed to journey to Assam and report on the tea growing wild there. The report of this committee stated that the tea plant as it flourished wild in Assam had degenerated and that the importation of China plants was advisable.

Accordingly an experimental plantation was started at Sadiya with seed imported from China. The first tea was planted on a river sand bank near the Brahmaputra and the result was a failure. The next area was put out, again with China seed, at Chabwa in the Dibrugarh District, because near here the Assam bush flourished wild. The result was a success. At this time Chinese were imported to work the gardens.

Bruce followed up his earlier discovery and later found tea in many tracts, the largest being at Namsang in the Naga Hills. Other big tracts were at Tipam and Gabru.

About the time Chabwa was planted, other small gardens round Tinsukia were also put out. In 1839 Lakhimpur and Sibsagar became part of the British Empire, and, soon after, the Government made over all its tea areas, with the exception of

Chabwa which had been sold to a Chinaman, to the Assam Company. In 1852 this company, the first tea company in India, paid its initial dividend. From this time on, the number of tea companies increased rapidly.

Meanwhile in 1855 indigenous tea was found in the Chankhani Hills in Sylhet and tea was put out in Cachar and Sylhet. Later on tea was found wild all along the Khasia and Jaintia Hills, and for some time the presence of indigenous tea was taken as the sign that the area was suitable for tea growth. The first tea in Cachar was put out in mauza Barsanjan in 1856, on the hill tops which stretched from the Barail range to the Barak. The *teelas* (hillocks) were next planted out and in 1875 the first *bheels* (swamps) were drained and planted. In Sylhet the first garden opened was Malnicherra in 1857.

About the same time Darjeeling embarked on the tea venture. By the end of 1856 tea plants had been cultivated at Tukvar, at the Canning and Hope Town plantations, on the Kurseong flats and between Kurseong and Pankhabari. After the industry was established as a commercial enterprise in the Darjeeling District, attention was paid to the Terai where Champta was put out in 1862. The land east of the Teesta was soon after explored and Gajaldhoba was planted in 1874, followed later by Phulbari (Leesh River) and Bagrakote. The tea area spread eastwards till it ultimately reached the Sankos, the boundary of Assam. Good *jat* indigenous tea was planted in place of the China bush with which the western Dooars and the Terai were planted.

The introduction of tea into Chittagong dates from the year 1840 when some China plants from the Botanical Gardens, Calcutta, and some seeds from Assam were planted in the pioneer garden in Chittagong, near where the Club now stands. This district is not favoured with a suitable climate and has not developed to any great extent.

Organization.

During the later decades of the nineteenth century many new gardens were opened out in Assam and were more or less family concerns. The later development has been in the direction of limited liability companies, and the tea industry to-day in North-East India is a highly organized one.

The length of the journey from England to India made tea agency houses a necessity in the earlier days, and to-day, with improved methods of communication and the shortened journey, the agency system is still in force, for it combines the benefits of a steady policy in garden management and co-operation among sellers in shipping and marketing their crops. Most agency houses also have their holdings in the concerns they manage.

The Indian Tea Association, Calcutta, was formed at a meeting of Calcutta tea agency firms in 1881, the object and duty of the association being to promote the common interests of all persons concerned in the cultivation of tea in India.

The Association started with a membership of companies and estate owners representing a planted area of some 103,000 acres, which had increased at the end of 1926 to 523,840 acres. This area represents approximately 88 per cent. of the area under tea in North-East India. In addition each district has its branch of the Association which deals with problems of local interest.

The tea industry in North-East India also has an Association for managing its labour affairs and for recruiting labour. As early as 1859 it was realized that the importation of foreign labour was essential and a Tea Planters' Association was formed for the purpose, among others, of organizing a system of coolie emigration from Lower Bengal to Assam. The sudden expansion of the industry created a class of contractors who supplied labour to the tea gardens which were so rapidly being established, and the planter came in most cases to have no more connection with recruitment than was involved in paying for the coolie. The results were so disastrous owing to competition between contractors that in 1861 Government appointed a committee to enquire into the system under which the emigration of labour was conducted.

As a result of this and other enquiries, various emigration acts were passed and finally in 1915 recruitment by contractors was abolished, and at present the only legal form of recruiting is done by garden sirdars working under a licensed local agent. A garden sirdar may be described as an individual employed on an estate as a labourer. The ideal is that such sirdars should recruit in their home district, preferably in and around their own villages. The duty of the local agent is to look after the interests of the garden sirdar.

In 1892 a meeting was called by the Bengal Chamber of Commerce to discuss the formation of an Association to deal with the question of labour supply to gardens. The outcome was the formation of the Tea Districts Labour Supply Association which took over the smaller Associations already in existence with the exception of the Assam Labour Association. The first recognition of the formation of these Associations was the granting of certain concessions by Government in connection with their operations. For instance, the power of local agents to act without the necessity of producing recruits before a magistrate was given.

In 1915 the Assam Labour Board was created to supervise the work of the local agents on behalf of Government. The Board was given the power to make recommendations regarding the licensing of local agents. Meanwhile the Assam Labour Association became amalgamated with the Tea Districts Labour Supply Association and in 1917 its denomination was altered to the Tea Districts Labour Association.

The Association is managed by a committee composed of members representing London and Calcutta interests and of planters from various tea districts. It is estimated that the Association controls recruiting for 95 per cent. of the estates in Northern India.

The Indian Tea Cess Committee was constituted under an Act the object of which was to provide for the collection of a fund to be expended for the promotion of the

interests of the Indian tea industry. From the year 1893, the Indian Tea Association had been collecting a voluntary assessment for expenditure on the development of foreign markets for Indian tea. There were, however, objections to raising money by this system, and the Association resolved, if possible, to make the levy a compulsory cess. The memorial presented to the Viceroy, praying for the imposition of a cess, was signed on behalf of proprietors and companies representing rather more than 80 per cent. of the tea area under tea cultivation in North-East India.

The Indian Tea Cess Committee is composed of twenty members representing the tea growers and the general commercial community.

The cess was levied at the rate of ¼ pie per lb. of tea exported (just over 2 annas per 100 lb.), and it remained at this rate till 1921-22 when at the instance of the industry it was raised to 4 annas per 100 lb. In 1923-24 the Act was amended, again at the instance of the industry, so as to enable the cess to be levied at the maximum rate of 8 annas per 100 lb. tea exported. The maximum rate has not been imposed so far, but in 1923-24 the levy was increased to 6 annas per 100 lb. of tea exported.

The cess is collected by the Customs Department and the proceeds are made over to the Cess Committee. An idea of the amount collected is given in the table below which shows the amount in the first year of the levying of the cess and in various other years.

	Rs.
1903-1904 at 2 as. per 100 lb.	2,66,894
1913-1914 „ 2 „ „ „	3,75,616
1921-1922 „ 4 „ „ „	7,44,334
1923-1924 „ 6 „ „ „	12,66,123
1925-1926 „ 6 „ „ „	12,28,526

At the time when the cess was instituted the Committee determined to concentrate their efforts largely on the United States of America. The work could not be carried on during the war, but in 1923 it was again taken up with vigour.

In continental Europe work started in 1905 in a small way in Belgium and Germany. The scheme steadily advanced till the outbreak of the war in 1914. Apart from gifts of tea to French and American troops little was done on the continent till 1925 when work began in France.

In the United Kingdom the Committee carried on an advertising scheme to counter the propaganda in favour of China tea. In the earlier years of the cess, contributions were made to a League formed with the object of bringing about a reduction in the duty on tea in the United Kingdom. Indian tea has also been represented at various exhibitions.

During the war, work was started in India on a large scale. No direct trading was undertaken by the Committee but funds were spent in encouraging the sale of tea by private enterprise. More than 40,000 bazaar shop-keepers have been influenced to take up the sale of tea. According to statistics the sale of tea in India

and Burma averaged approximately 18 million lb. annually for the quinquennium before the start of the propaganda work in India. During the year ended 31st March, 1926, the estimated quantity of tea available for consumption in India and Burma was over 50 million lb.

The Indian Tea Association has a well staffed and well equipped Scientific Department for investigating the various problems connected with tea culture and manufacture. The department was first started in a small way in 1900 following on a resolution passed at the annual general meeting of the Association in 1899. Immediately after that meeting the opinions of the branches of the Association were sought regarding the appointment of a scientist. The preponderance of opinion was distinctly in favour of the appointment of an Agricultural Chemist, and Mr. Harold H. Mann, B.Sc. (now D.Sc.), F. I.C., was selected in London and engaged on a three years' agreement. The initial estimated expenditure of this appointment was reckoned at Rs. 1,500 monthly, which had to be met from the surplus funds of the Association, augmented by grants from the Government of Bengal and the then Administration of Assam, and from additional contributions from the different branches of the Association. The initial sanction for laboratory equipment was £200. The laboratory work was inaugurated in conjunction with the laboratory accommodation in the Economic Court of the Indian Museum, Calcutta, where laboratory accommodation is still enjoyed by this Association.

From these small beginnings the Scientific Department has developed into an institution employing a European qualified staff recruited from Home, consisting of a Chief Scientific Officer, three Chemists, an Entomologist, a Mycologist and a Bacteriologist, together with Indian qualified assistants and others.

In 1926 the estimated expenditure of the department was Rs. 2,33,726 which is met by the money collected in subscriptions on an acreage basis from all tea companies in the membership of the Association.

Details concerning the work of the department are given later.

COMMUNICATIONS.

It is no exaggeration to say that the development of Assam and the Dooars is wholly due to the tea industry. Communications have always presented a difficulty partly on account of unbridgeable rivers and partly because the tea areas are thinly populated.

Dibrugarh, the premier tea district, is 830 miles by railway from Calcutta, the business headquarters of the industry. The Terai, the district nearest Calcutta, is 340 miles from that centre. The main traffic artery of Assam was, until the beginning of the present century, the Brahmaputra, and a service of paddle steamers plies between Calcutta and Dibrugarh, a distance of about 1,000 miles which is covered in a fortnight. The outlet for districts on the north bank of the river is still by steamer as far as Gauhati (Pandu),

In the Surma Valley, the Barak river was the main outlet before the railway was opened, and much tea is still brought by country boats to this river where it is transhipped to steamers.

The first railways in Assam were the Jorhat Provincial Railway, 2 ft. gauge, and the Dibru-Sadiya Railway, metre gauge, both built with the object of connecting tea districts with the Brahmaputra. The importance of the big river as a means of communication began to wane when the Assam Bengal Railway, metre gauge, was constructed from Chittagong to Tinsukia where it joined the Dibru-Sadiya Railway. This railway was built largely for strategic purposes and crossed the Barail range of hills from Cachar into the Assam Valley at Lumding. This outlet was an expensive one, for the railway crossed the hills at the geological fault between the Naga Hills and the Jaintia Hills with the result that land slips were common and through traffic was often suspended.

In the meantime the line from Lumding to Gauhati had been constructed and an alternative route to Calcutta was by railway to Gauhati and then by river steamer to Dhubri, where the Eastern Bengal Railway was joined. The last link in the chain of communication between Calcutta and Assam was made when the line from Lalmanirhat to Amingaon, opposite Gauhati, was opened. During the last few years several important branch lines have been constructed in Assam.

The Dooars is served by the metre-gauge Bengal Dooars Railway which joins the Eastern Bengal at Lalmanirhat, where the line from Assam to Calcutta is joined. This line continues to Santahar where it joins the broad gauge line from Siliguri. Tea must be transhipped at Santahar. An alternative exit for tea from the Dooars is *via* Dhubri on the Brahmaputra where the tea is transhipped to the river steamer and taken direct to Calcutta.

The Surma Valley is in direct railway communication with Chittagong. To get to Calcutta it is necessary to change at Chandpur and go by steamer to Goalundo whence the broad gauge section of the Eastern Bengal runs to Calcutta.

With the advent of motor traffic the need for good roads has become apparent, since most gardens employ motor lorries and motor cars are used extensively by the planting community. The Assam Valley is particularly unfortunate so far as roads are concerned because very little suitable metal is available on the south bank, where most of the tea gardens are situated. The roads are accordingly of earth and are thick either in dust or mud according to the season. Many places are isolated in the rains except for bullock cart traffic.

In the Surma Valley some of the roads are better partly because laterite from the *teelas* is available and partly because much of the traffic is down the small rivers, thus reducing the cart traffic on the roads.

In the Dooars, road metal is plentiful and the roads are numerous and good all the year round. The trouble here is the rivers which cut the district transversely and are difficult or expensive to bridge.

So far as communications are concerned, both by road and railway, the Terai is the most favoured tea district in North-East India. The railway centre is Siliguri whence the broad gauge runs direct to Calcutta.

Darjeeling suffers the inconveniences of transport which are unavoidable in a hilly district. In many cases the main trouble is to get the tea to the Darjeeling Himalayan Railway, a 2 ft. gauge line, which runs from Darjeeling at a height of about 7,000 feet to Siliguri in the plains where it joins the broad gauge to Calcutta.

Statistics.

Practically all the black tea consumed comes from India, Ceylon, Java and China. Japan produces green tea which is unfermented and Formosa a distinctive tea, partly fermented, known as Oolong. China produces both green and black tea. No definite figures regarding the acreage under tea in China are available. The table below shows the approximate acreage under tea in the principal exporting countries.

	Acres
India	716,000
Ceylon	403,000
Java and Sumatra	250,000

The tea areas in the Dutch Indies are rapidly expanding, whilst the Ceylon acreage is almost stationary although about another 20,000 acres are available for tea. The Indian acreage is increasing steadily.

The tea area in India is made up as follows :—

	Acres
Assam	412,859
Bengal	181,833
Bihar and Orissa	2,099
United Provinces	6,119
Punjab	9,709
Madras	48,647
Tripura (Bengal)	4,793
Travancore	50,166
TOTAL	716,225

The area in Assam and Bengal constitutes what is spoken of as tea in North-East India. The small areas in Bihar and Orissa, the United Provinces and the Punjab are not organized as is the main area. The Travancore and Madras areas make up what is known as South India so far as tea is concerned.

The acreage in North-East India is made up as shown below. Cachar and Sylhet are known collectively as the Surma Valley. The Brahmaputra Valley is that area of Assam east of Gauhati and is often spoken of as the Assam Valley. The district called the Dooars is officially known as Jalpaiguri and is situated at the foot of the Himalayas between the Teesta and the Sankos rivers. Darjeeling includes the

Terai where about 20,000 acres are under tea. The Darjeeling District is the only elevated tea area in North-East India, tea being planted up to heights above 6,000 feet, although the general altitude is 3,000 to 4,000 feet.

	Acreage	No. of gardens
Brahmaputra Valley	268,105	586
Cachar	57,756	165
Sylhet	86,998	155
Dooars	117,576	132
Darjeeling and Terai	58,747	166
Chittagong	5,510	29
TOTAL	594,692	1,233

The total area in occupation by tea planters is 2,000,133 acres, much of the land given in grant being used for rice cultivation by the coolies on the garden and smaller areas being given over to grazing and to forest grown mainly for fuel. In some districts practically the whole of the area under grant is opened out in tea, and here there is usually a difficulty in keeping coolies who regard a piece of land for rice cultivation as essential.

The growth of the area under tea is shown in the table below which gives the areas in Assam and Bengal.

Year	Assam Acres	Bengal Acres
Average 1885-1889	211,301	73,169
„ 1900-1904	338,250	136,153
1914	376,375	159,304
1924	412,859	181,833

The total production of tea in North-East India has increased at a greater rate than has the acreage because the output per acre has shown a steady general increase.

Year	Assam	Bengal
	lb.	lb.
Average 1885-1889	66,677,373	19,376,597
„ 1900-1904	141,105,749	48,707,794
1914	208,552,307	75,373,201
1924	237,153,110	87,121,205

The total tea thus produced in North-East India in 1924 was 324,274,315 lb., of which 1,178, 744 lb. was green tea. The average production over the past ten years is 327 million lb., touching 350 million lb. in 1917 and falling to 242 million lb. in 1921, the slump year.

The tea is exported from Calcutta and Chittagong. In 1924-25 Calcutta dealt with 220,090,121 lb. and Chittagong with 79,656,694 lb. The difference between production and shipments is a measure of the amount of tea consumed within India.

That India is well maintaining her position in the tea world is shown by the table below. The figures illustrate the enormous increase in Indian export (these figures refer to all India) and the smaller, but still great, increase in Ceylon exports. Java, which only seriously entered the market in about 1900, has shown the greatest percentage increase, whilst China has shown a serious falling off. The figures in brackets show percentage changes.

Year	India	Ceylon	China	Java
	lb.	lb.	lb.	lb.
1896-97 . .	150,421,245 (100)	110,095,194 (100)	240,106,266 (100)	....
1905-06 . .	216,770,366 (144)	171,256,703 (156)	152,936,800 (76)	25,650,156 (100)
1915-16 . .	192,593,938 (194)	208,090,279 (189)	205,520,533 (86)	98,006,121 (382)
1924-25 . .	348,476,011 (232)	204,931,217 (186)	102,124,666 (42)	105,113,200 (410)

The figures for China include black, green, brick and tablet tea and dust.

A study of the yield of tea per acre in both Assam and Bengal is instructive in that it illustrates the steady increase up till the end of 1919, followed by a drop. This is due to the post war slump when accumulated stocks of tea in England reduced the price of the current stocks of tea below the cost of production. After the slump the tea was in a poor state owing partly to the stoppage of manuring during the war years and lack of cultivation during the lean years following. The smaller irregularities in crop due to seasonal variation and pests and blights are masked by taking the five-year average.

Period	Assam	Bengal
	lb. per acre	lb. per acre
1885-89	316	265
1890-94	358	292
1895-99	361	330
1900-04	416	361
1905-09	477	425
1910-14	531	468
1915-19	614	554
1920-24	527	423

The averages suppress the yields from various districts of course. In 1924 the average yield in Assam was 576 lb. per acre and in Bengal 479 lb. per acre. The chief districts gave the following yields in that year.

	lb. per acre
Lakhimpur (Dibrugarh)	752
Sibsagar	614
Darrang	576
Jalpaiguri (Dooars)	588
Darjeeling	330

Each district produces tea of some peculiar merit. Darjeeling teas sell largely on their flavour. Assam teas are valued for pungency and, at some periods of the year, for appearance. Dooars teas sell for strength and in the autumn for flavour. Cachar and Sylhet teas are generally inferior to those from other districts.

The average price of teas from the various districts sold in London in 1925 was as follows :—

	Average price per lb.
Assam	17·93*d.*
Cachar and Sylhet	14·52*d.*
Darjeeling	19·02*d.*
Dooars	16·11*d.*

The tendency during the past few years has been for the prices of teas from the poorer districts like the Dooars and Cachar and Sylhet to approach those of Assam.

(*To be continued.*)

THE ECONOMIC HOLDING OR THE FAMILY FARM.

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(*Concluded from Vol. XXII, Pt. VI.*)

France.

In the first part of this article an attempt was made to guage how much land was required in Italy to give a family enough to live on and enough to do, and it was seen that it depended largely upon the system of farming, and that while the market-gardener could live on two or three acres, the arable farmer might require fifty or even a hundred. Now let us see how much is needed in France. This we are able to do, thanks to an official enquiry made in 1908-09 when every department or district submitted a report in the form of a monograph on its agricultural conditions.[1] These show that at least 48 districts have areas wholly, or almost wholly, given up to cereals. In only four is the dividing line between the peasant and the medium proprietor put at less than 25 acres—Haute-Savoie (20 acres), Loire Inférieure (12½), Pyrénées Basses (12½) and Haute Saone (15). And it is significant that in the first two, as in Modena, dairying is of importance, while in the third emigration is a factor, and in the fourth the small proprietor does no more than live.[2] In 29 districts, the line of division is drawn at over 25 acres; in 15, it is as high as 50, and in Oise, which recalls the Italian Marches and the Maremma, it runs up to 125.[3]

In forty districts, there are areas devoted entirely, or almost entirely, to 'petite culture.'[4] In eighteen the line for this class of cultivation is drawn at less than five acres, and in only one at over 12½ acres. Round Paris, as around Naples, less than 2½ acres can support a family. In this area, before the war, there were twelve to thirteen hundred market-gardeners with holdings of slightly less than 2 acres each. They maintained themselves and their families by getting six or seven crops a year out of their land, and by their industry and constant manuring they have raised its value tenfold. In Vaucluse, which is described as 'le departement priviligié de la petite culture,' the cultivation of asparagus and the strawberry raised it before the war from 20 to 2,400 francs an acre. This has not been done by labour only, but by labour in combination with glass frames, forcing houses, heating apparatus and pipes.[5]

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[1] *La Petite Propriètè Rurale en France*, 1909.
[2] *Ibid*, p. 210.
[3] *Ibid*, p. 175.
[4] *Ibid*, p. 226.
[5] *Ibid*, p. 262.

Speaking generally, the different reports suggest that for cereals 25 to 50 acres are needed, for 'petite culture' 2½ to 12½ acres, and for a mixture of both 12½ to 25 according to the proportions of the mixture. The correspondence between these figures and the Italian is remarkable. The following points must, however, be noted.

Firstly, cereals are nearly always combined with stock-breeding or dairying, or with both; and in addition there is the produce of the poultry yard, the garden and the orchard, and there may be a plot of tobacco as well. Pigs, too, are generally kept and sometimes sheep and goats; and occasionally carting is done or cider made. The more these different elements are combined and the more science is applied, the nearer the limit can be to ten acres. Where the peasant is described as doing well on less than 25 acres he is usually said to use artificial fertilizers, improved implements like harrows and hoes, and even a machine or two, such as a small reaper or thresher. And where the small holder is able to hold his own with the large in cereals areas, he owes it to the help derived from his poultry-yard, dairy, pigs and stock.

Secondly, as in Italy, market-gardening nearly always seems to be due to the neighbourhood of a town or factory or to some special climatic advantage combined with first-rate transport facilities. The bulk of the market-gardener's produce has naturally to be sold, and as it perishes quickly it has to be sold at once. If, therefore, there is no market in the neighbourhood, it must be possible to reach other markets quickly. First and foremost, there must be roads, and it may be said that without good roads there can be no market-gardening away from a town. And, if distant towns are to be reached, there must also be good railways. In France, cabbages, peas, onions and artichokes are sent in masses from Brittany to England, Switzerland and Belgium; and flowers are grown in the Riviera to adorn the tables of London and Paris, to such effect that before the war an acre of land produced from £100 to £130 a year and yielded a net profit of from £16 to £32.[1]

In Italy the proprietor clings to his holding at all costs, but the 87 monographs of the French enquiry suggest that the French peasant is not prepared to accept the low standard of living involved in a very small holding or to live on it at the price of running into debt. He either limits his family or buys more land, or if he cannot buy, takes it on lease in the hope of being able to purchase it later. Or, if this again is beyond him, he goes out as a labourer. If the worst comes to the worst, rather than live a miserable life upon the land, he sells it and migrates to the town or goes abroad.[2] The advantage of this rural exodus is that it enables those who remain to enlarge their holdings, and this is why in France, but not in Italy, such holdings have increased in area rather than number.[3]

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[1] *Ibid*, p. 20; and Laribé, *L'Evolution de la France Agricole*, 1912, pp. 71-4

[2] *Ibid*, p. 275.

[3] *Ibid*, p. 68.

Belgium.

From France it is but a step to Belgium, and it is a step worth taking for the purpose of this study, as Belgium is essentially a country of small holdings—61 per cent. are of ten acres or less [1]—and it is as highly organized as any country in the world. Organization has been forced upon it by the density of its population (666 per square mile), which is greater than that of any other country in Europe.[2] Cultivation is even more intensive than in Denmark, and credit and co-operation almost as strongly developed.[3] Cereals form the basis of cultivation, and wheat, barley, oats and rye alternate with roots and fodder crops.[4] Sugar-beet and flax are also of great importance, while the area under potatoes is nearly 10 per cent. of the whole. Fertility is maintained by the abundant use of manure—before the war more artificial manure was used per acre than in any other country in the world[5] —and by the application of scientific rotations ; and so successful is this, that two crops a year are frequently obtained[6] and the average yield of wheat is 38 bushels an acre against 14 in the Punjab.[7] The growing of crops is supplemented by the breeding and fattening of live stock. No other country carries so many cattle to the acre,[8] and the same applies to pigs, which everyone keeps.[9] Poultry, too, are universal, and horses as well as cattle are fattened in thousands.[10] To illustrate the variety of stock maintained, a farm of 27 acres (the size of a ' square ' in Lyallpur) is quoted as maintaining a mare, 4 milch cows, 3 heifers, 3 calves, 3 pigs, 3 sows, 10 piglets, 40 hens and 20 rabbits—total value Rs. 2,800. The peasant labours all day to make both ends meet and is greatly assisted by wife and daughters. These look after the poultry, the pigs, the kitchen garden and the dairy, feed the calves, and dig the potatoes, weed, hoe and help in the hay-making, at harvest time tie the corn into sheaves and build up the stooks, and sometimes even spread the manure on the fields and lift the turnips.[11] Dairymaking, apiculture, distilling and brewing are common and provide a useful resource for those who cannot find enough to do at home. In Flanders, there is a brewery in nearly every village of importance, and sprinkled over the country are factories for the manufacture of fertilizers, for making chicory for coffee and for extracting syrups from pears, apples and beetroot.

Yet, in spite of all these advantages of resource, effort and organization, a farmer and his family cannot support life on less than ten acres—in two districts,

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[1] Max Rasquin, *L'Agriculture Belge*, 1920, p. 6.
[2] *Cf.* England and Wales, 649 ; Punjab, 183 (*Census of India*, 1921, XV, 2).
[3] *Cmd 2145*, Mr. D. H. Macgregor's report, paragraph 162.
[4] In 1908, 1·76 million acres were under cereals, and 2·40 million under roots, fodder and leguminous crops (*Notice Sur L'Economie Rurale de L'Agriculture*, 1910, p. 13).
[5] Rowntree, *Land and Labour*, 1910, p. 223-24.
[6] *Ibid*, p. 179.
[7] For Belgium see *Manchester Guardian Commercial*, 17th August 1919, and for the Punjab, Roberts and Faulkner, *A Text-book of Punjab Agriculture*, 1921, p. 5.
[8] M. Rasquin, *op. cit.*, p. 14.
[9] Rowntree, *op. cit.*, p. 181.
[10] In 1910, 85,000 cattle were fattened and 35,000 horses exported (M. Rasquin, *op. cit.*, p. 15).
[11] *Ibid*, p. 201.

Campine and Polders, where vegetables are widely grown, the minimum is 7½—and over most of the country ten to twenty are required to give a family of five or six enough to live on and enough to do. In Condroz and the Ardennes, fifty acres are said to be necessary for comfortable living, but in the one cultivation is entirely arable and in the other the land is mostly forest and pasture. These figures agree strikingly with those for Italy and France, and they are of special interest, as they are based upon the type of cultivation which, with no doubt a wide difference of degree, prevails in the Punjab. If we substitute sugarcane, cotton and maize for sugar-beet, oats and rye, there is no great difference in crops, but a difference of heaven and earth in cultivation and system of farming.[1]

Importance of live stock.

On the first point, all that it is necessary to say is that before the war 1½ million tons of manure per annum were put into less than 4¾ million acres.[2] As to the system of farming, the most marked point of contrast is the part played by live stock. We have already had occasion to refer to the importance of this in the case of France, where, in cereals areas, the peasant 'pays his way with his crops and makes his profit out of his cattle.'[3] In greater or less degree, this appears to be the case throughout northern and central Europe, wherever market-gardening or the growing of some specialized crop like the vine is impossible. This is clearly brought out by some recently published figures for Denmark, Norway, Sweden and Switzerland, which show, in the case of 379 farms, the proportion contributed to total income in 1922-23 by crops and live stock. The farms are classified in three groups according to their size, but figures will only be given for the 225 farms of 25 acres or less, as this is the class with which we are mainly concerned. The Norwegian figures will also be omitted, as there are only six farms in the group. The others are as follows[4] :—

—	Number of farms under 25 acres	Percentage of the total gross income derived from	
		Crops	Live stock
Denmark	45	7	88
Sweden	26	9	84
Switzerland[5]	158	10	60

[1] My authority for most of the facts given above (except where otherwise stated) is the series of eight monographs, one for each district, published by the Belgium Ministry of Agriculture from 1899 to 1902.

[2] Rowntree, *op. cit.*, pp. 223-4.

[3] *The Punjab Peasant*, *op. cit.*, 2nd Edition, p. 291.

[4] E. Thomas, *The Economics of Small Holdings*, 1927, pp. 108-11.

[5] The size of the Swiss farms is 12½ to 25 acres.

In none of these countries do the crops contribute more than ten per cent. of the total income, and in all three live stock contributes 60 per cent. or more. How this is made up is shown in the following table :—

	Cattle	Dairy produce (included in cattle)	Pigs	Miscellaneous (horses, sheep, poultry, etc.)
Denmark	44	36	33	11
Sweden	49	37	20	15
Switzerland	48	31	8	4

In each case, nearly half the total income is derived from cattle. These are described as the 'sheet anchor' of the small holder. The anchorage is the dairy, which is responsible for about one-third of the total income. A noticeable point is that in all three countries "the milk industry is organized almost entirely upon co-operative lines."[1] After cattle come pigs, an item that for religious reasons would rarely figure in a Punjab peasant's account. Their great importance in Denmark is due to the fact that with dairy cattle they are the basis of Danish farming. This explains the very high percentage for Denmark in the first table. A minor point, but not without interest, is that in all three countries "increasing importance is attached to the culture of bees."[2]

Summary—Italy, France and Belgium.

The amount of land that is required to support a family in modest comfort and give it enough to do has now been considered in three different countries, the first in southern, the second in central, and the third in northern Europe. Broadly, we find that in all three the market-gardener can live upon two or three acres, and even upon less when conditions are particularly favourable. And in a temperate climate, where nature is kindly and needs simple, the grower of the vine and the olive, the orange and the lemon, the potato and tobacco, can live on four or five. Where these are combined with cereals in more or less equal proportions, he will require from five to ten. But where cereals preponderate, the peasant needs from ten to twenty. These figures all postulate highly intensive farming, that is to say, cultivation based upon scientific rotations and a sufficient supply of manure and water. In the case of arable farms, they further postulate the breeding and fattening of different varieties of stock. Where these conditions are absent and farming is more or less primitive, or where it is based mainly upon pasture, from 25 to 50 acres, and occasionally more, are required to support any reasonable standard of living.

[1] *Ibid*, p. 13.
[2] *Ibid*, p. 114.

Other European Countries.

That these figures are generally typical of Europe is suggested by the information obtained for other countries. When I was in Germany, I found that in the thickly populated and highly industrialized valley of the Rhine the market-gardener, like his fellow round Naples and Paris, can maintain himself and his family on less than two acres.[1] At the gates of a western German town, says Wygodzinsky, five acres will support a family handsomely.[2] Where cereals predominate, ten or twelve acres are required. In southern Germany, which is much less industrialized, a family can just maintain itself on 12½ acres, but only if the land is fertile, the farming good and live stock is bred. Two and a half acres will be under wheat, 2½ under hay, a little perhaps under tobacco, and there will also be fruit trees and poultry.[3] But though this is possible, 12½ to 25 acres are usually required in the south, 25 to 37½ in the centre and 37½ to 50 in the north.[4]

In Holland, we are reminded of Belgium. There, as in Campine and Pôlders, with good land and the help of cattle, poultry and pigs, the arable farmer can manage on 7½ acres, and on 12½ he can save. But this, my informant stated,[5] was due to the free use of manure and a highly developed system of co-operation, which secured to the farmer the maximum price for his produce. In Denmark, where farming is based upon cattle and pigs, a law of 1925 enacts that land shall not be alienated unless enough remains to support a family. The limits are 17½ acres for good land and 35 for bad.[6] To us in India these limits seem high, but enquiry into the conditions of over 500 farms in 1922-23, a very good year, showed that the owner of an average farm of 14½ acres earned only £1 more than a hired labourer.[7]

In England, owing to a very high standard of living, limits are highest of all. In the richest part of the country, the Isle of Axholme, 'ten acres is the smallest area on which a man can support a family without any other industry to help him,'[8] and where there is no live stock industry or market-gardening, twenty are needed.[9] Of Oxfordshire it is said that, apart from market-gardening and expert poultry-keeping, 'there is no system of cultivating land which will yield a family an adequate maintenance from less than thirty acres;'[10] and of Yorkshire, that no one should

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[1] *Some Aspects of Co-operation in Germany, Italy and Ireland*, 1922, p. 22, by the author.
[2] *Agrarwesen und Agrarpolitik*, 1920, I, 43.
[3] Information given me by a German expert at the International Institute of Agriculture, Rome.
[4] Wygodzinsky, *op. cit.*, I, 44. *Cf.* the following from Cmd 2145 (paragraph 81 of Mr. D. H. Macgregor's report):—"Even less than 5 acres in market-gardening districts may afford a comfortable subsistence to a hard-working family, and much more than 50 in other districts may be inadequate. But it is generally agreed in Germany that the 5 to 50 acre group of holdings does, on the whole, represent pretty nearly the type of properties which are big enough and not too big 'to occupy and maintain a family.'"
[5] The Dutch Delegate at the International Institute of Agriculture.
[6] *The Punjab Peasant*, *op. cit.*, 2nd Edition, p. 290.
[7] Thomas, *op. cit.*, p. 125.
[8] H. W. R. Curtler, *A Short History of English Agriculture*, 1909, p. 318.
[9] A. W. Ashby in *The Economic Journal*, March 1917.
[10] A. W. Ashby, *Allotments and Small Holdings in Oxfordshire*, 1917, p. 117.

be given a holding of less than 35 acres or even fifty.[1] In Wales, where the small holder still flourishes, it was recently found in Camarthenshire that of those who had fifty acres or less and who were 'entirely occupied on their land and getting full sustenance therefrom,' only 4½ per cent. were able to do so on ten acres or less, and most of them were market-gardeners or poultry farmers. Another twelve per cent. had ten to twenty acres, and 62½ per cent. thirty to fifty.[2] But conditions in the United Kingdom are peculiar and have little affinity with those prevailing in India. For this, we must go to the other side of Europe—for instance, to Roumania and Poland. In Roumania, in districts of mixed farming, the limit of small holdings is put at twenty-five acres, and where cultivation is 'extensive,' at fifty.[3] In Russian Poland it would appear from St. Reymont's remarkable novel, *The Peasants*, that the peasant proprietor can live on six or seven acres. "Mercy on us"! exclaims Boryna, when asked to settle six acres on his bride, "Six acres! It is a whole farm"[4]! But in this village, fruit, vegetables, poultry and pigs are combined with cereals. How common this is in Europe and how important to the well-being of the peasant, is one of the main points emerging from this study, and it is a point in sharp contrast to conditions in India.

The Punjab.

MARKET-GARDENING.

To these conditions we must now turn our attention, for this study would not be complete if we did not make some attempt to ascertain how much land is required to support a family of four or five in India. In considering this most vital question I propose to confine myself to the Punjab, as it is the province I know best and a wider enquiry would take us too far afield. Even with this limitation, the question can only be answered in the most general terms, as there is very little material on which to base an opinion. Over sixty tehsil assessment reports, covering a period of twenty years (1907-26), have been searched for information, but only five consider the question at all.[5] I have, therefore, had to rely to a large extent upon general enquiries made from settlement officers and others in close touch with agricultural conditions. Let us take the market-gardener first. He is generally an Arain or Saini, except in the North where, as likely as not, he is a Maliar. The Arain is seen at his best round Amritsar, Sialkot and Jullundur, and the Maliar on

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[1] *International Review of Agricultural Economics*, March 1927, p. 157.

[2] Thomas, *op. cit.*, pp. 26-7.

[3] I. L. Evans, *The Agrarian Revolution in Roumania*, 1924, pp. 150-51.

[4] Vol. I (*Autumn*), p. 221: see also Vol. IV, p. 110 where another character says:—'Six whole acres! 'Tis all but a farm by itself!'

[5] Nawashahr, 1916.
Ambala, 1918.
Kot Adu, 1924.
Tallagang, 1925.
Attock, 1925.

the banks of the Indus in the fertile strip of country known as the Chhachh.[1] In the intensiveness of its cultivation, the Chhachh recalls the country round the Bay of Naples, where, as we have seen, the market-gardener can live on 1¼ to 2½ acres. In the Chhachh, he can live on one to 1¼ acres, and many live on less. A family consisting of an old man, a grown-up son, two women, three small children, a buffalo and a donkey were recently discovered living on less than half an acre. The old man, who was only an occupancy tenant (fortunately at a low rent), did most of the tillage using the buffalo for the well and the plough, while his son used the donkey for carrying the vegetables to Campbellpur and Rawalpindi, the latter thirty or forty miles away. In another village, a Maliar was found supporting his wife and four small children on three-quarters of an acre, though half of every thing produced, vegetables, maize and tobacco, had to be given to the landlord.[2] Both cases are only possible because snuff-tobacco, a most valuable crop, is grown and irrigation is by well. In the Peshawar District, where snuff-tobacco is also grown but irrigation is by canal, more land is needed, as less water can be obtained from a canal than a well, and it cannot always be obtained when it is wanted. Round the larger towns in the central Punjab, where irrigation is mainly by well but snuff-tobacco is unknown, two acres are normally required, though the Arain round Sialkot can manage on one. It may be said, therefore, that in the Punjab, the market-gardener can live on one or two acres and prosper on three. In this, there is no marked difference between the Punjab and the West. The main difference lies in the fact that in the West the market-gardener plays a much more important part. In Belgium, for example, over two per cent. of the cultivated area is devoted to garden produce against less than one per cent. in the Punjab, and in addition nearly ten per cent. is under potatoes.[3]

ARABLE FARMING.

Coming to arable farming, we must distinguish two types : firstly, the more or less intensive type based upon holdings of a few acres and upon an assured water supply derived from canal or well ; and secondly, the extensive type based upon somewhat larger holdings and a more or less capricious rainfall. The latter closely resembles the type which still prevails over a large part of southern Italy and Sicily, where the rainfall is uncertain and cultivation primitive. A good example of it

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[1] For a description of this tract, see *The Punjab Peasant, op cit.*, 2nd Edition, p. 89.

[2] *Attock Assessment Report*, 1925, p. 19.

[3] In the Punjab, the average area under orchards and garden produce for the three years ending 1925-26 was 288,883 acres (*Season and Crop Reports*). This includes 47,442 acres in Mianwali, 40,000 acres of which was given up to the extensive cultivation of the melon. In Belgium, the cultivated area in 1895 was 4·7 million acres (Rowntree, *Land and Labour*, 1910, p. 176) and in the same year the area devoted to garden produce and potatoes was 104,670 and 461,727 acres, respectively (*Notice sur L'Economic Rurale*, 1910, p. 12). In Italy, before the war, the area under vegetables alone was 525,000 acres (*L'Italia Agricola*, 1920, II, 183) out of a total cultivated area which in 1924 was 32 million acres (*International Yearbook of Agricultural Statistics*, 1924, p. 50) : *cf.* 30 million for the Punjab.

in the Punjab is the Tallagang tehsil in the north with an average rainfall of 21 inches. In this area, it is estimated that a family of four can just live on fourteen acres, but only if a certain amount of live stock—cattle, camels or goats—are bred for the market.[1] In the Ambala tehsil, which has a rainfall of 32 inches, it was found that a man could with difficulty support a wife, five children, and three dependents on 25 acres.[2] This family is, of course, much larger than the ordinary family, which in the Punjab averages 4·5. In the *barani* tracts of Rohtak with a rainfall of only twenty inches 'the zemindar reckons to keep a pair of plough cattle for twenty to thirty acres,'[3] which suggests that he cannot comfortably live on less. In Montgomery, where only ten to fifteen inches of rain can be expected in a year and (outside the colony) cultivation depends largely upon the precarious supply of the inundation canal, it is reckoned that forty to fifty acres are required to support a family in reasonable comfort. This may be compared with the large holdings of the Sirsa tehsil, where cultivation depends almost entirely upon an average rainfall of twelve inches.[4]

Where the water supply is assured, the amount of land required varies with the intensiveness of the farming. This is greatest in Jullundur, where well irrigation prevails and profitable crops like sugarcane, cotton and wheat can be grown. When the district was last settled (1914-16), the normal holding was five acres, which at first sight suggests that this is enough for an ordinary family to live on.[5] This, however, is almost certainly not the case, for about two-thirds of the owners are in debt, and many have land in the canal colonies and not a few emigrate.[6] For the humbler castes with their very simple standard of living five or six acres may possibly suffice, of which, indeed, we have an example in a Mehton of Nawashahr, who was found to have brought up a family of five sons and two daughters, without getting into debt, on 5½ acres of irrigated land. He grew sugarcane, cotton, wheat, maize, chillies, gram, barley, vegetables and fodder,[7] and the fact that he married all but one son and spent over Rs. 1,400 on a single wedding shows what can be done, even with arable farming, when water, fertility, energy, and thrift are all combined. But the case is altogether exceptional and would probably not have been possible had not vegetables and chillies been amongst the crops

[1] The hypothetical family consisted of a man, his wife and 2 children aged 12 and 5 (*Assessment Report*, 1925, pp. 15-6).

[2] *Assessment Report*, 1918, pp. 8-9.

[3] *Rohtak Assessment Report*, 1909, p. 11.

[4] In Sirsa, holdings average 60 acres per owner (*Assessment Report*, 1921, p. 9).

[5] To obtain the normal holding, the following holdings were excluded :—

(1) Those consisting of an entire estate, (2) small plots given to religious persons and village menials, (3) those held in usufructuary mortgage, (4) those occupied by well-cylinders, threshing floors, etc., (5) Government and Abadi holdings, and (6) holdings of occupancy tenants paying low rates. In three tehsils, the normal holding was found to be five acres, and in the fourth (Nawashahr) to vary from four to eight acres, according to the circle, see *Assessment Reports*.

[6] *The Punjab Peasant, op. cit.* p. 44.

[7] *Assessment Report*, 1916, p. 14. The exact area was 58 Kanals, 13 Marlas. In Jullundur 10·537 Kanals make an acre.

cultivated. Owing to the large number of Arains in Jullundur, the vegetable plays a more important part in this district than in most, and the more this is the case, the smaller the area required for the family farm. Recently in the Arain village of Tehong, three miles from Phillour, it was found that more than half the cultivators (226 out of 438) were living on 2½ acres or less. This apparently they were able to do, as each holding had about an acre under vegetables.

Though the normal holding in Jullundur is only five acres, and Arains, by cultivating vegetables and accepting a low standard of living, live on less, the lowest estimate given me for the central Punjab, where irrigation is by well or by canal and well combined, is seven acres.[1] (Compare the 7½ acres quoted for Holland and the two Belgian districts of Campine and Polders.) But all whom I have questioned agree that if a family is to live comfortably, the minimum will be ten to fifteen acres, according to the nature of the cultivation. This agrees with the results of a survey recently carried out, under the writer's supervision, in a village near Lahore. The land is canal-irrigated and under wheat, rice, cotton, and fodder. No vegetables are grown, but a good deal of stock is carried, as Lahore provides a first rate market for milk, which nearly every one sells. It also gives abundant opportunities for carting, which is done for four months in the year. Enquiry shows that, under these very advantageous conditions, ten acres will support a family of five (including three children), provided there is no debt, which is not usually the case. Thanks to the carting, there will also be enough work, though the actual field labour takes only 180 days. But if no milk could be sold in Lahore and no carting done, it is estimated that fifteen acres would be required instead.[2]

The Canal Colonies.

The canal colonies require separate consideration, as their conditions are peculiarly favourable. Holdings are substantial and also compact, and crops are secure and debt light. On the other hand, irrigation is by canal which is less productive than irrigation by well, and the standard of living is higher than anywhere else. For Lyallpur, the lowest estimate given me is 13½ acres or half a square, and for Montgomery, where less water is available and cropping consequently less intense, it

[1] In the Samrala tehsil of Ludhiana, where irrigation is by river flood or by well and crops are apparently secure, five to six acres are said to provide an ample holding. The ordinary rotation is maize, cane and wheat (*Assessment Report*, 1910, pp. 16 and 19).

[2] For a ten-acre holding income and expenditure are estimated, thus :—

	Income Rs.		Expenditure Rs.
Produce	350	Cultivation	287
Sale of milk	108	Personal—Food	140
Carting	160	Dress	50
		Social functions	50
Total	618	Miscellaneous (no interest charges included)	77
		Total	604

is twenty acres. Recently, exact accounts have been obtained for a number of farms in both areas. The result, in the case of eighteen Lyallpur farms, shows an average *net* income of Rs. 49-6 per acre.[1] A farm of 13½ acres, therefore, would produce about Rs. 667 a year. On this income the ordinary cultivator elsewhere would probably consider himself affluent, but then he is nearly always in debt, and his standard of living is low. The last point is of importance, and it may be emphasized that the figures taken from the Assessment Reports are based on the very modest standard of the past, while the colony figures postulate the higher standard desired for the future and already partially realized in Lyallpur. The difference is well illustrated by the Kot Adu tehsil of Muzaffargarh, a district in which the standard of living is lower than in any part of the province. Here, it is said, five *cropped* acres will maintain a family.[2]

The Lyallpur enquiry brings out three points which, though generally accepted in theory, are not always accepted in practice. The first is that the modern system of farming is more remunerative than the old. One of the estates, for which accounts were kept, consisted of 88 acres divided into three farms, which were given out to tenants on the *batai* system. The land was of average quality, but was cultivated on modern lines. Seed was carefully selected, up-to-date implements used, and expert supervision applied. The result was a net income of Rs. 87 per acre as against only Rs. 59 for three other estates, totalling 184 acres.[3] The second point illustrates the value of substituting fruit and vegetables for ordinary crops. A tenant who did this obtained Rs. 1,085 by the sale of oranges and onions from land which would otherwise have brought in only Rs. 200.[4] The last point is that intensive farming provides not only more cash, but, what in this case is equally valuable, more work. It was found that the cultivation of an acre provided from 17 to 20 days' work in the year, but that in one case it gave 22 days. This was because the tenant in question put twice as much land under sugarcane as usual. For the 18 farms examined, the average was 170 days' work in the year,[5] which, it may be noted, is well within the estimate already given for the Punjab as a whole. As the average area of these 18 farms is almost exactly 13 acres, or slightly less than half a square, it would seem that though half a square may give a family enough to live on it will not give it enough to do. It is one of the problems of the family farm that it is difficult to combine both.

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[1] H. R. Stewart, *Some Aspects of Batai Cultivation in Lyallpur District*, 1926, pp. 32-34.

[2] *Assessment Report*, 1924, p. 10.

[3]

Size of estate Acres	Net profit per acre Rs. A. P.
28	66 9 0
46½	56 7 6
110	58 0 0
Average of 184 acres	59 (round)

[4] Stewart, *op. cit.*, p. 8.

[5] *Ibid*, p. 4.

THE PUNJAB COMPARED WITH THE WEST.

We may now compare the farmer in the Punjab with the farmer in the West, and we may say that the Arain of Tehong and the Mehton of Nawashahr, with their combination of vegetables, chillies, cotton and sugarcane, correspond with the grower of the vine and the olive, the orange and the lemon, and that all three can live on four or five acres. And the arable farmer of the central Punjab and the canal colonies may be said to correspond with the arable farmer of Italy, France and Belgium, who requires from ten to twenty acres for the support of a family. Finally, the large holdings of the insecure *barani* tracts may be compared with the twenty-five to fifty acres required under somewhat similar conditions in Italy and France. The comparison suggests a rough approximation in the area required for the family farm in each category. But in the case of northern Europe it may be urged that the comparison has little value, as the standard of living and the conditions of life are totally different from those prevailing in the Punjab. There is obvious force in this argument, and we must bear it in mind in drawing conclusions from Belgium and France. But it applies much less to Italy, and hardly at all to Sicily and the south of the peninsula. Conditions in the latter, as I hope to show in a subsequent article, have much in common with those in the Punjab, and it would seem as if in both countries the purely arable farmer cannot maintain himself and his family in any degree of comfort on less than ten or twelve acres, without running into debt or finding some supplementary means of subsistence. Such figures as we have suggest that three-quarters of the cultivators of the Punjab have ten acres or less to cultivate,[1] and in the rest of British India, except in Bombay and the N.-W. Frontier Province, holdings would appear to be, if anything, smaller.[2] What chance then is there of prosperity for the Indian cultivator, whose farming is still the primitive farming of the ages, whose land, as population increases, is more and more subdivided, whose fields are fragmented almost beyond belief, who often has not enough water and rarely enough manure, who seldom knows how to grow either vegetables or fruit, who is generally in debt and has to borrow most of his capital at 18 or 25 per cent., who is obliged by custom to spend at least a year's income on every marriage, and who, if a Hindu, is virtually debarred by religion from being a successful breeder of cattle ? In such a case, how could a cultivator be anything but poor ? Man in India has multiplied too fast and is too thick upon the ground. The increase of over fifty millions in the last fifty years has confirmed the sentence of poverty unwittingly passed long ago by the people on themselves.[3] Can this sentence be reversed ? Can it even be mitigated ? The experience of western Europe suggests that much can be done, but only if holdings are consolidated, resources developed and the rapid increase of population arrested.

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[1] *The Punjab Peasant*, *op. cit.*, 2nd Edition, p. 3 (footnote).
[2] *Ibid*, p. 288.
[3] The population of India rose from 265 millions in 1872 to 319 millions in 1921 (*Census of India*, 1921, I, 7).

COIMBATORE SEEDLING CANES.

(CO.'s 205, 210, 213, 214, AND 223 DESCRIBED AND ILLUSTRATED.)

BY

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I. INTRODUCTION.

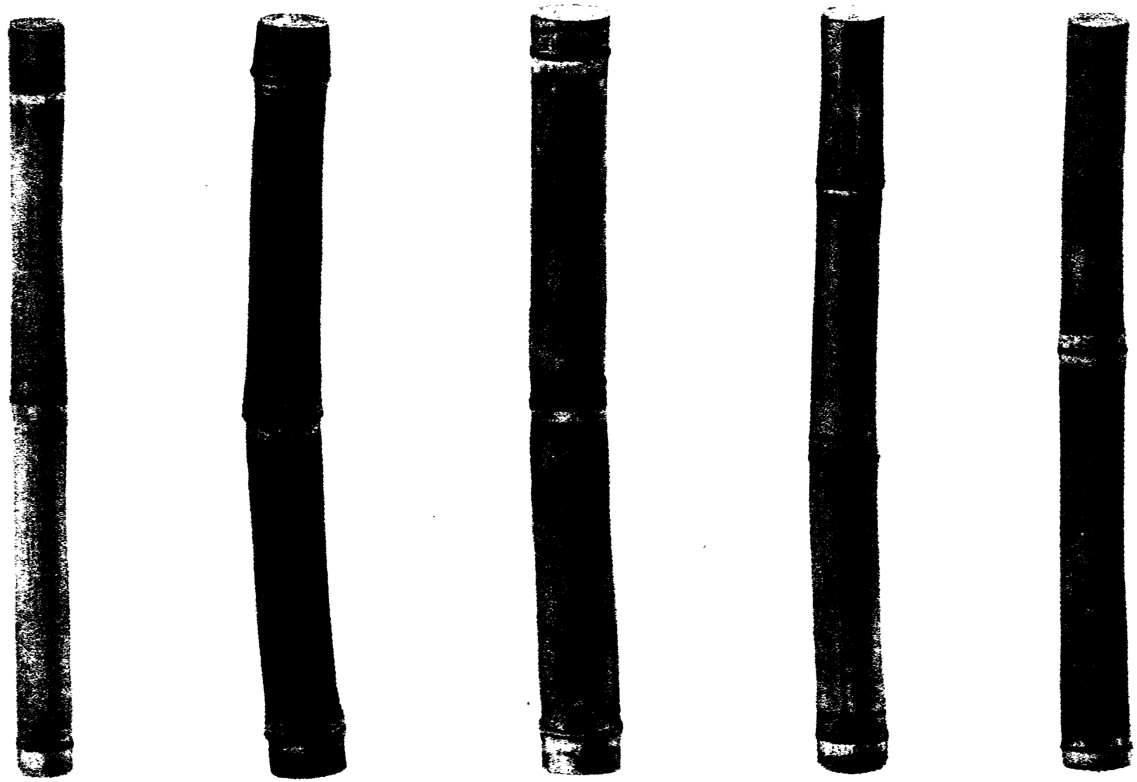
WITH the rapid spread into cultivation of more than one Coimbatore sugarcane seedling in sub-tropical North India—at the time of writing the area under such seedlings is computed at over 60,000 acres—it has been thought desirable to present in this paper brief descriptions of the more popular of them. Unlike as in most other plants, the floral parts are very rarely used in the identification of cane varieties, some of them never flowering in ordinary cultivation. Descriptions of canes, like the ones herein given, have therefore to be based largely on the vegetative characters of the plant. Besides the descriptions a certain amount of information has been included on the root systems of the seedlings.

II. NATURE AND SCOPE OF DESCRIPTIONS.

When attempting the descriptions, various difficulties were experienced. It was found, for instance, that the same seedling showed differences in leaf curvature, length and thickness of joints and nature and quantity of vestiture on various parts of the plant, according to the locality in which it was grown. This is not to be wondered at, when the wide variations in climatic and other conditions of growth, between the different parts of India, are considered.

Technical words have been kept at a minimum in these descriptions to render them useful to a wider class of readers. Secondly, no attempt has been made to describe the seedlings for all the characters, which are over seventy in number. Only such of the characters are described and illustrated, as would bring out the essential features of the seedling or are of use as separation characters. In

Coimbatore Seedling Sugarcanes.



Co. 205 Co. 210 Co. 213 Co. 214 Co. 223

preparing these notes the elaborate morphological descriptions by Drs. Barber[1] and Jeswiet[2] and the popular descriptions by Cowgill[3] have been freely consulted.

An attempt has been made to fully illustrate the descriptions. The various seedlings have attained their greatest popularity in definite localities; and it has been thought best to base the descriptions and illustrations in this paper on material collected from such localities. The material for Co.'s 205 and 223 was obtained from the Punjab and that for Co.'s 210, 213 and 214 from Bihar. The illustrations include one set of paintings (Pl. III) showing the natural colour of the canes prepared from mature formaline-preserved material. Further, a plate of line drawings has been included of each seedling (Pls. IV to VIII) to illustrate certain of the parts described and is placed facing the descriptions to facilitate reference.

III. Characters described.

(*a*) *Parentage.* Each description starts with the parentage of the seedling. Details about parentage have not perhaps the same importance in the sugarcane as in most other crops; very wide variations are found even in batches of carefully 'selfed' seedlings and the inheritance of characters in the sugarcane has not yet been traced to very definite laws. It needs to be mentioned, however, that certain indications have been obtained in this matter[4]; and, in the past, a judicious selection of parents has led to practical results.

(*b*) *Habit and general appearance.* The general appearance of the crop in the field is of considerable help in the identification of canes and, sometimes, enables the separation of varieties otherwise very similar. The habit of the plant, the number, colour, arrangement and type of canes in the stool, and the nature, colour, quantity and width of the leaves are certain of the characters contributing to this general appearance. These are described in general terms for each seedling.

(*c*) *Leaf.* The sugarcane leaf is divisible into two main parts, *viz.*, the *lamina* or the expanded green portion and the *sheath* or that portion of the leaf which clasps the cane and carries the lamina at its top.

(1) *Lamina.* (Pl. IV, fig. 1)—

(i) The lamina (lam)* is described for its *length and width* in relative terms. No attempt has been made to give the maximum, minimum or the

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[1] Barber, C. A. Studies in Indian Sugarcanes. No. 1—Punjab Canes. *Mem. Dept. Agri. India, Bot. Ser.*, Vol. VII, No. I.

[2] Jeswiet, J. Beschrijving der Soorten van het Suikerriet. *Mededeelingen van het Proefstation voor de Java-Suikerindustrie,* Landbouwkundige Serie, 1918, No. 5, pp. 383-413.

[3] Cowgill, H. B. A Method of Identification and Description of Sugarcane Varieties and its Application to Types grown in Porto Rico. *Jour. Dept. Agri., Porto Rico,* Vol. I, No. 3, 1917.

[4] Venkatraman, T. S. Sugarcane Breeding—Indications of Inheritance. *Mem. Dept. Agri. India, Bot. Ser.,* Vol. XIV, No. 3, and *Archief voor de Java-Suikerindustrie.*

* Here and elsewhere the contraction within brackets represents the symbol by which the part is indicated in the plates.

average measurements for these or any other quantitative character, as these not only vary from one locality to another but are of little use in field identification.

(ii) While the youngest leaves in a cane plant are more or less erect, the older functioning leaves show *curvatures* often characteristic of each cane and the leaves are therefore described for this character. A representative leafy tuft is illustrated as Fig. 1 for each seedling.

(2) *Sheath* (Lf sh. Fig. 1) possesses certain characters which are of use in identification. Three of the more important and easier ones are described for each cane. These are :—

(i) *Spines* or stiff silicious hairs on the back or the dorsal side of the sheath. These may be present, indicated or absent, and, when present, show a certain amount of variation in nature and quantity.

(ii) *Ligular processes* (Lig Pro. Pl. IV, figs. 2 and 3). These are scarious lateral extensions of the sheath generally pointing towards the apex of the lamina and arising from the junction between the sheath and the lamina. These may be long or short, broad or narrow, tooth-like or sharp pointed, curved, present on one or both sides, merely indicated or altogether absent. When differences exist, this is a very easy and useful character in the identification of sugarcane varieties.

(iii) *Ligule* (Lig. Pl. IV, fig. 3). This is a membranous appendage of the leaf-sheath extending upwards from the point of union of the sheath and blade. This shows variations in more than one respect. The size and the shapes of the upper and lower margins are described.

(*d*) *Cane or stalk.* (1) *General.* Two characters which are easily noticed in a batch of stripped canes going to the mill are 'thickness' and 'shape' of the cane as a whole. Both these are easy of recognition even by a layman and have been included in the descriptions.

(2) *Colour.* Colour was one of the earliest characters used in cane classification and, previous to the discovery of the large number of morphological characters, often used to form the major portion of cane descriptions. At the same time it is by no means a very reliable character ; it varies not only with the locality and stage of growth of the plant but also with exposure to light and sun. The blushing of canes with exposure is a common enough experience with cane growers. Again, not only do individual canes in a clump differ from one another, but even parts of the same cane show a certain amount of variation. In these notes the aim has been to describe the colour in bulk, of a representative lot of canes, leaving out minor variations.

(3) *Joint or internode.* This is the portion of cane between two adjacent nodes (Pl. V, fig. 5). At the base of each joint and immediately above the node is a fairly well defined region the 'root zone' with rows of transluscent dots which are in reality the incipient or resting root tips. When the cane is planted in the ground the first roots of the germinating cane arise from these transluscent dots. Above the root zone is a ring of often meristematic tissue called the 'growth ring' (G. R.). This is generally a well defined ring often of a colour different from the rest of the joint.

The joint possesses a large number of characters and some of the useful ones are described. These are :—

(i) *Shape* of individual joint. This sometimes differs, according as the joint is viewed with the bud towards the observer or to one of his sides. The shape referred to in these descriptions is of the joint with the bud towards the observer.

(ii) *Groove* (Pl. V, fig. 4) or the longitudinal depression in the joint extending upwards from the 'eye' or bud. This is present only in certain canes and, when present, may be shallow or fairly deep and extending practically along the whole length of the joint or over a portion of it.

(iii) *Ivory markings* (I. M. Pl. IV, fig. 4) are thin lines, really cracks, in the epidermis and differ in nature, quantity and distribution.

(iv) *Splits* (Spl. Pl. IV, fig. 5) are deeper cracks in the epidermis and, like the ivory markings, vary in quantity and distribution.

(4) *Bud.* At the base ot each joint is found the bud. In popular language it is also called the 'eye' or 'point.' This is really the embryo shoot and renders possible the vegetative multiplication of the cane as is the case in ordinary cultivation.

Though comparatively small, it possesses many characters of diagnostic value. It has recently been even claimed that varieties could often be identified[1] from buds alone, if these are well preserved. Most of the characters in the bud are however rather minute and do not lend themselves for use in popular descriptions. Two of the easily recognizable characters have been included. These are :—

(i) *Size and shape.*

(ii) *Flange* (Fl. Figs. 6 and 7). This is the flattened edge of the bud formed by the outer scales. It varies in origin, width and vestiture.

(e) *General remarks.* Short notes are here given based on the performance of these seedlings in various provinces.

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[1] Jeswiet, J. Beschrijving der Soorten van het Suikerriet. *Mededeelingen van het Proefstation voor de Java-Suikerindustrie,* Landbouwkundige Serie, 1918, No. 5, pp. 383-413

IV. Descriptions.

(a) Co. 205.

(a) *Parentage.*

Vellai ♀ × *Saccharum spontaneum* ♂. Bagged cross. The mother arrow possessed very few (2 per cent.) slightly open anthers, and as other stray pollen was kept out by enclosing the mother arrow in a muslin bag it may be taken to be a cross between the parents indicated.

(b) *Habit and general appearance.*

Habit erect. Good stand of thin canes frequently splitting and generally with a pronounced leafy tuft; lodges in rich soils and with irrigation. Foliage abundant.

(c) *Leaf.*

(1) *Lamina.*

(i) *Length and width.* Long; narrow.

(ii) *Curvature.* Younger leaves erect, older broadly curved. Under moist conditions older leaves tend to develop a sharper curve.

(2) *Sheath.*

(i) *Spines.* Present, often numerous.

(ii) *Ligular process.* Present, long pointed one side, short and blunt the other side.

(iii) *Ligule.* Broad, upper margin deeply arched, lower slightly depressed.

(d) *Cane.*

(1) *General.* Thin, fairly straight.

(2) *Colour.* Glaucous green with a tinge of yellow at base of joints.

(3) *Joint.* Shape straight sided. Groove absent. Ivory markings numerous. Splits common.

(4) *Bud.*

(i) *Size and shape.* Small to medium; generally obovate, flat.

(ii) *Flange.* Not conspicuous, rising below middle and of uniform width with a number of whitish shining hairs.

(e) *General remarks.*

A hardy and hard rinded thin cane of great vigour, rather late in maturing and with a comparatively low quality juice. Resists frost, drought and water-logging and is specially suitable to unfavourable conditions of growth because of its remarkable root system.

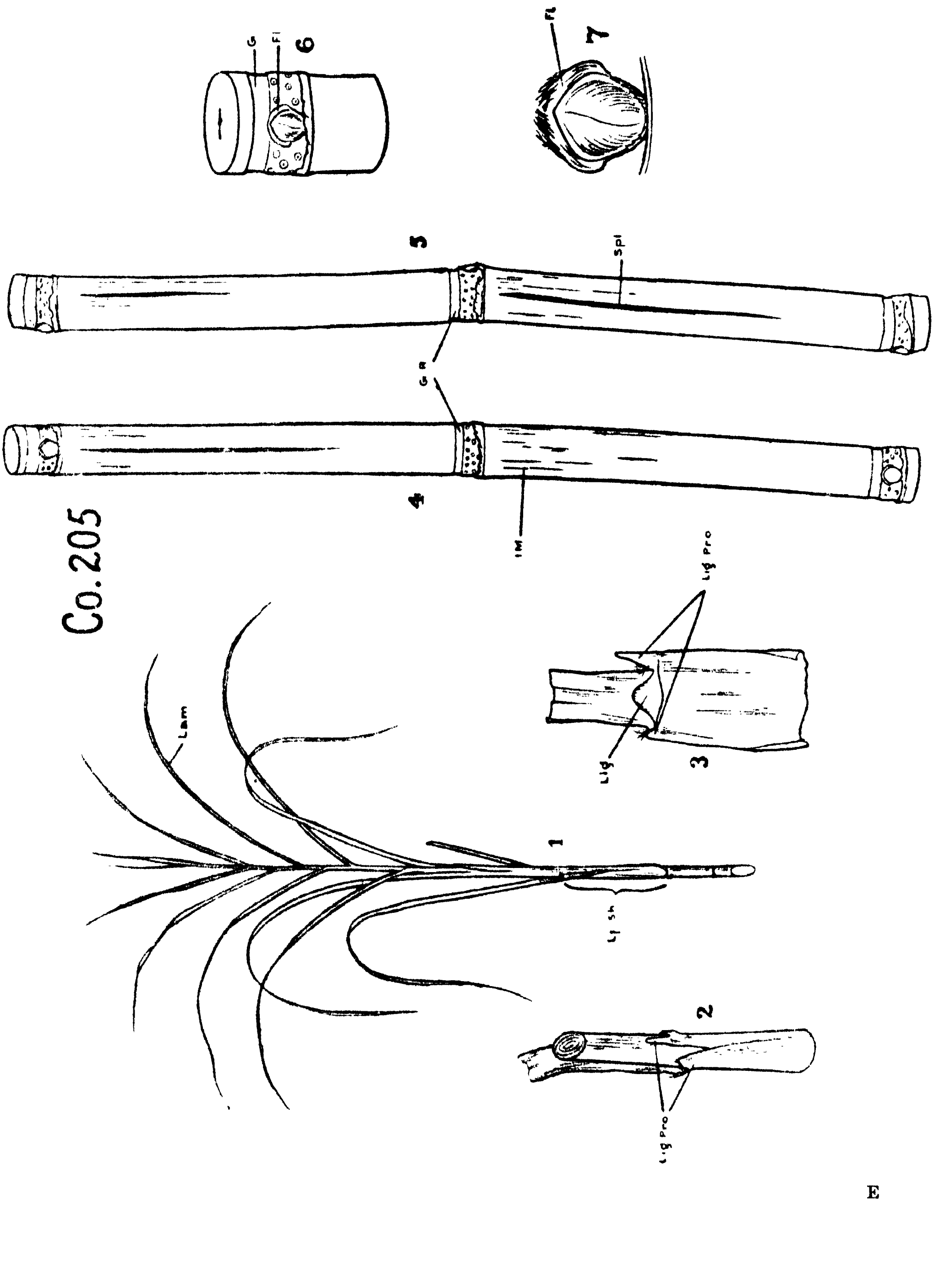
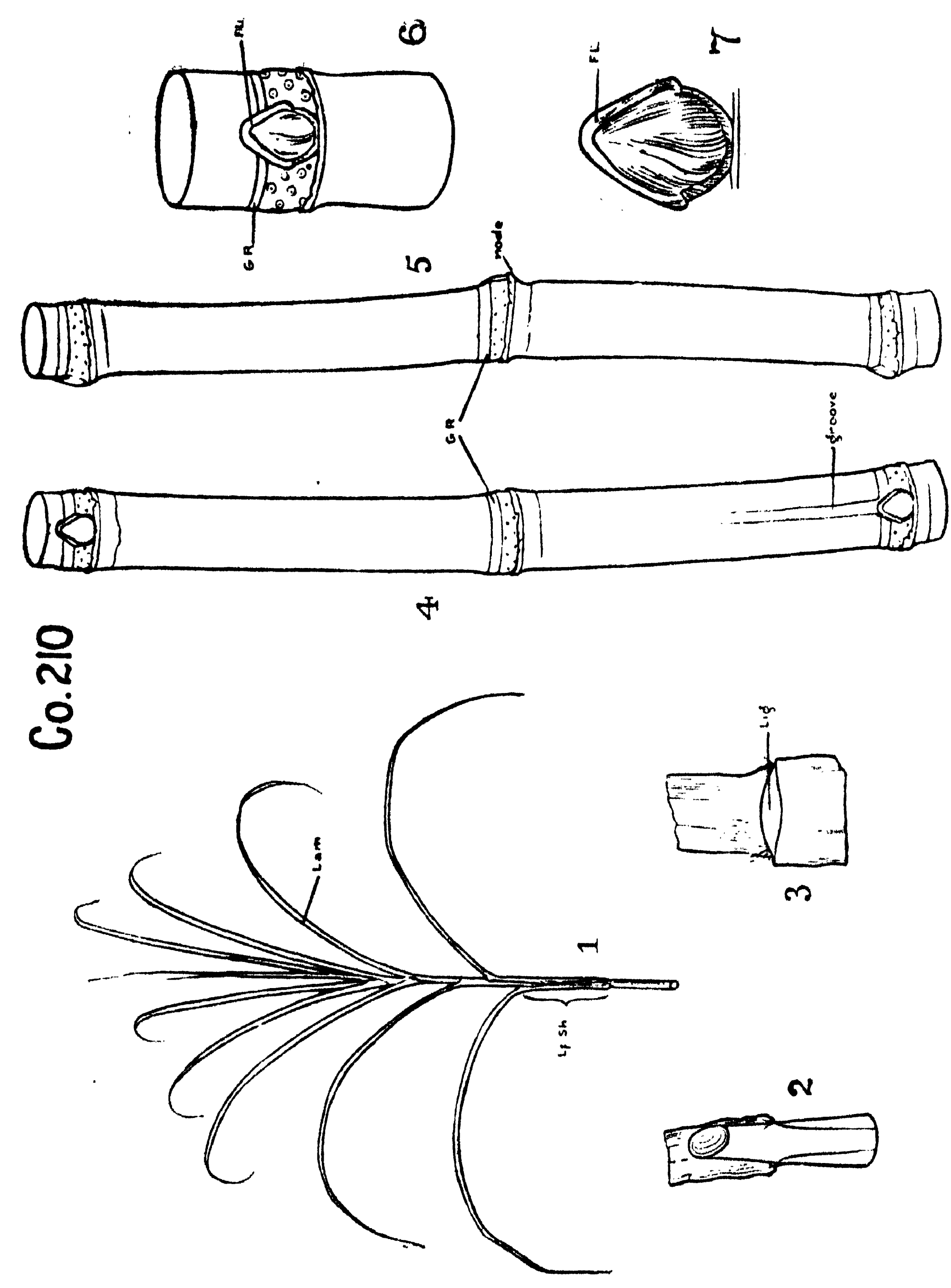

Co. 205
1
Lam
Lf Sh
2
Lig Pro
3
Lig
Lig Pro
4
IM
GR
5
Spl
6
G
Fl
7
Fl

PLATE V.



(b) Co. 210.

(a) ***Parentage.***

P. O. J. 213 ♀ × Unknown ♂. General collection. The mother variety has no healthy pollen, therefore not selfed. Likely cross with M. 2 or M. 1017, two vigorous Madras seedlings of rather low sucrose which were flowering freely in the neighbourhood.

(b) ***Habit and general appearance.***

Habit fairly erect. A good stand of canes slightly swollen at the nodes and of less than medium thickness; lodges under very favourable conditions of growth. Foliage medium.

(c) ***Leaf.***

(1) *Lamina.*

(i) *Length and width.* Long; medium.

(ii) *Curvature.* Younger leaves sharply curved at tips, older broadly curved.

(2) *Sheath.*

(i) *Spines.* Often present, but not numerous.

(ii) *Ligular process.* Practically absent.

(iii) *Ligule.* Of medium width, upper margin broadly arched, lower slightly depressed.

(d) ***Cane.***

(1) *General.* Less than medium in thickness, fairly straight.

(2) *Colour.* Varying shades of brownish purple, lighter and sometimes with a tinge of yellow at base of joints.

(3) *Joint.* Shape practically straight sided, sometimes concave on the eye side and convex on the opposite. Groove present, sometimes pronounced. Ivory markings absent. Splits absent.

(4) *Bud.*

(i) *Size and shape.* Large, often extending beyond growth ring: ovate, rather flat.

(ii) *Flange.* Not conspicuous, rising below middle, often broadening towards apex.

(e) ***General remarks.***

A fairly hardy sub-medium cane with good ratooning power; resists frost, drought and water-logging better than Co. 213 and matures earlier.

(c) Co. 213.

(a) *Parentage.*

P. O. J. 213 ♀ × *Kansar* ♂. Unbagged cross. The mother variety has no fertile pollen, so not selfed. May be a cross with *Kansar* whose pollen was artificially dusted over the stigmas, or with M. 2 which was flowering freely nearby.

(b) *Habit and general appearance.*

Habit erect. A good number of close straight medium thick canes; in the very early stages the plants have a markedly depressed habit. Foliage medium abundant.

(c) *Leaf.*

(1) *Lamina.*

(i) *Length and width.* Rather short; broad.

(ii) *Curvature.* Fair number of younger leaves erect resulting in a fanlike appearance, older more or less broadly curved.

(2) *Sheath.*

(i) *Spines.* Rare, sparse.

(ii) *Ligular process.* Absent.

(iii) *Ligule.* Of medium width, upper margin arched, lower slightly depressed.

(d) *Cane.*

(1) *General.* Of medium thickness, straight.

(2) *Colour.* Ground colour straw yellow superposed with pink or brown and with a tinge of green on top portions of joints, blackening frequently shown off against the ground colour; growth ring yellowish to brownish.

(3) *Joint.* Shape barrelled with often a slight bulge at base of joint on the other side of the bud. Groove sometimes present, not prominent. Ivory markings occasional, short, greyish. Splits absent.

(4) *Bud.*

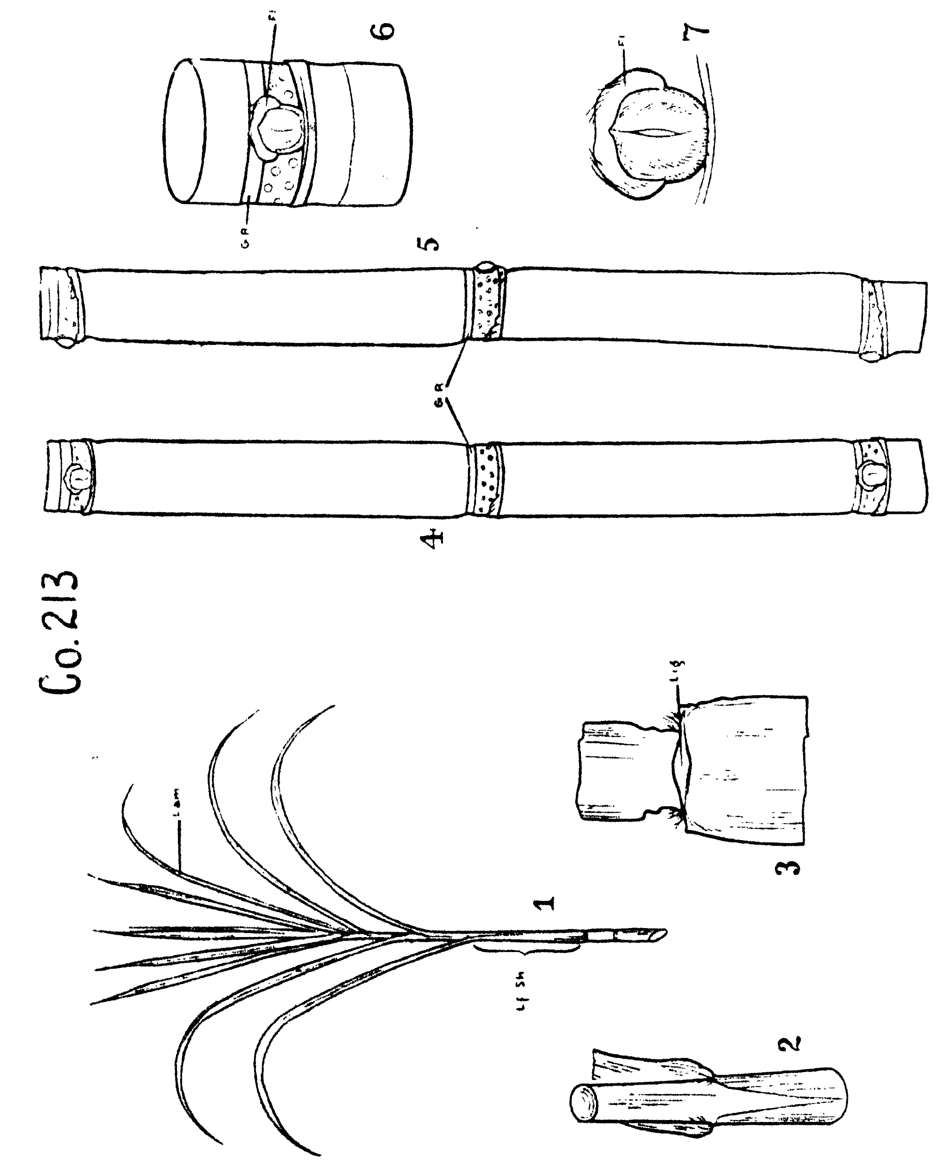
(i) *Size and shape.* Medium; sub-orbicular, plump.

(ii) *Flange.* Sometimes conspicuous, rising at about middle and of uniform width.

(e) *General remarks.*

A medium cane of great vigour and an excellent habit at maturity, though with a markedly depressed habit during the earlier stages of growth.

Roots abundant, but not so strong as in Co. 205 or Co. 210.



Co. 213
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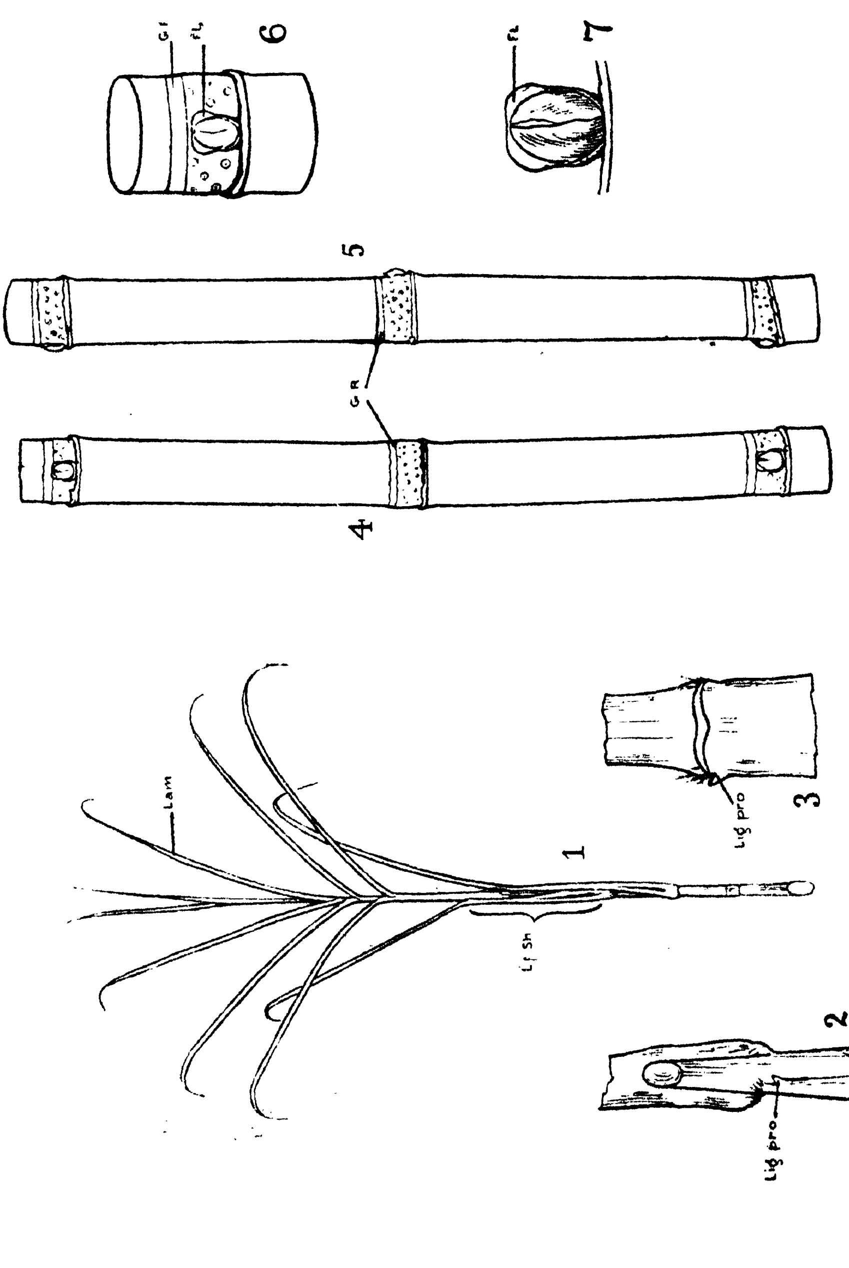
PLATE VII.



(*d*) Co. 214.

(*a*) *Parentage.*

Striped Mauritius ♀ × M. 4600 ♂ (*Saretha* ♀ × *S. spont.* ♂). Unbagged cross. The mother variety has a fair quantity of pollen. The stigmas were constantly dusted with pollen of M. 4600. Other seedlings raised from *Str. Mauritius* are of a totally different type. The seedling is therefore a likely cross between the parents indicated.

(*b*) *Habit and general appearance.*

Habit often reclining to spreading. A fair number of thin often curved canes and a scant tuft of leaves. Foliage rather meagre.

(*c*) *Leaf.*

(1) *Lamina.*

(i) *Length and width.* Short ; rather narrow.

(ii) *Curvature.* Young leaves erect or sharply curved at tips, older straight, greater part of the length and the tips either sharply or broadly curved. Older leaves developing minute well defined longitudinal light coloured patches sometimes yellowish.

(2) *Sheath.*

(i) *Spines.* Absent.

(ii) *Ligular process.* Often present on one side, short and pointed.

(iii) *Ligule.* Of medium width. upper margin bow-shaped, lower depressed.

(*d*) *Cane.*

(1) *General.* Canes thin, frequently curved, feebly zig-zag in lateral view.

(2) *Colour.* Generally greenish yellow, sometimes yellowish green ; blushing green ; occasionally developes blotches of coral towards maturity.

(3) *Joint.* Shape straight sided. Groove indicated or absent. Ivory markings occasional, short, greyish. Splits rare.

(4) *Bud.*

(i) *Size and shape.* Small to medium ; oval or sub-ovate, rather plump.

(ii) *Flange.* Not prominent, rising about or above middle, slightly broadening at sides and narrowing towards apex ; often depressed at apex.

(*e*) *General remarks.*

A thin to medium cane of moderate vigour often with a bad habit and hence crooked canes, difficult to transport. Earliest in ripening and with a high quality juice.

(*e*) Co. 223.

(*a*) *Parentage.*

Chittan ♀ × Unknown ♂. General collection. Some vigorous *Naanal* seedlings, which possess an abundance of healthy pollen, were flowering on the windward side, and cross-pollination with these is highly probable. Arrows of *Chittan*, collected under conditions where selfing was most likely, gave a different type of seedlings.

(*b*) *Habit and general appearance.*

Habit erect. A fair number of straight canes of less than medium thickness. Foliage medium.

(*c*) ***Leaf.***

(1) *Lamina.*

(i) *Length and width.* Medium ; more than medium.

(ii) *Curvature.* Younger leaves fairly erect : older often with a sharp almost angular bend at middle.

(2) *Sheath.*

(i) *Spines.* Often present, fair amount.

(ii) *Ligular process.* Often absent, sometimes indicated.

(iii) *Ligule.* Of medium width, upper margin broadly arched, lower depressed.

(*d*) ***Cane.***

(1) *General.* Sub-medium to medium in thickness, straight.

(2) *Colour.* Light pinkish purple, ashy on account of the overlying wax layer ; root zones whitish ; growth ring yellow.

(3) *Joint.* Shape thinning up. Groove absent. Ivory markings moderate amount. Splits few.

(4) *Bud.*

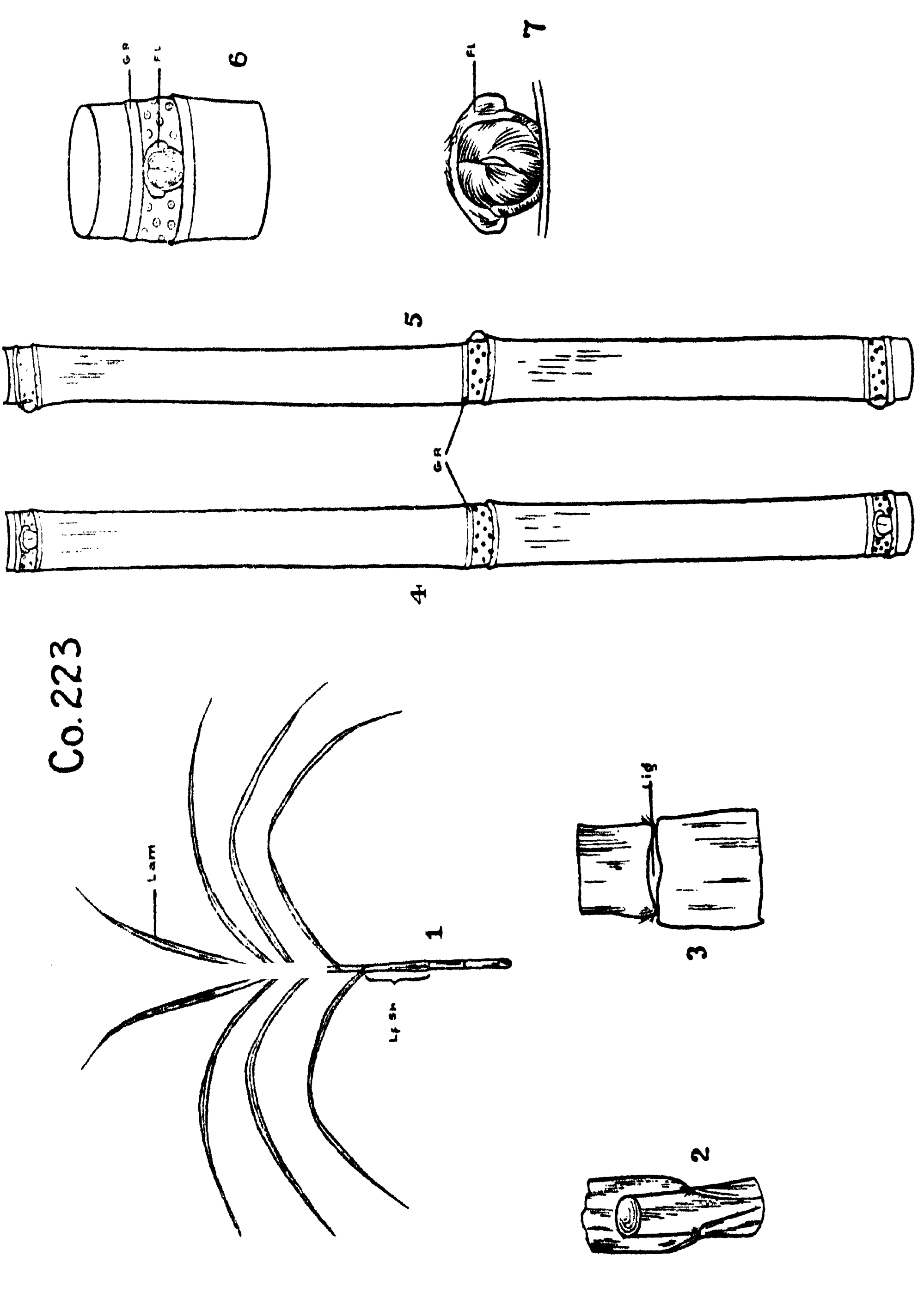
(i) *Size and shape.* Medium : generally orbicular, plump.

(ii) *Flange.* Conspicuous, rising about middle, broad at origin, narrowing round apex with few short sparse hairs.

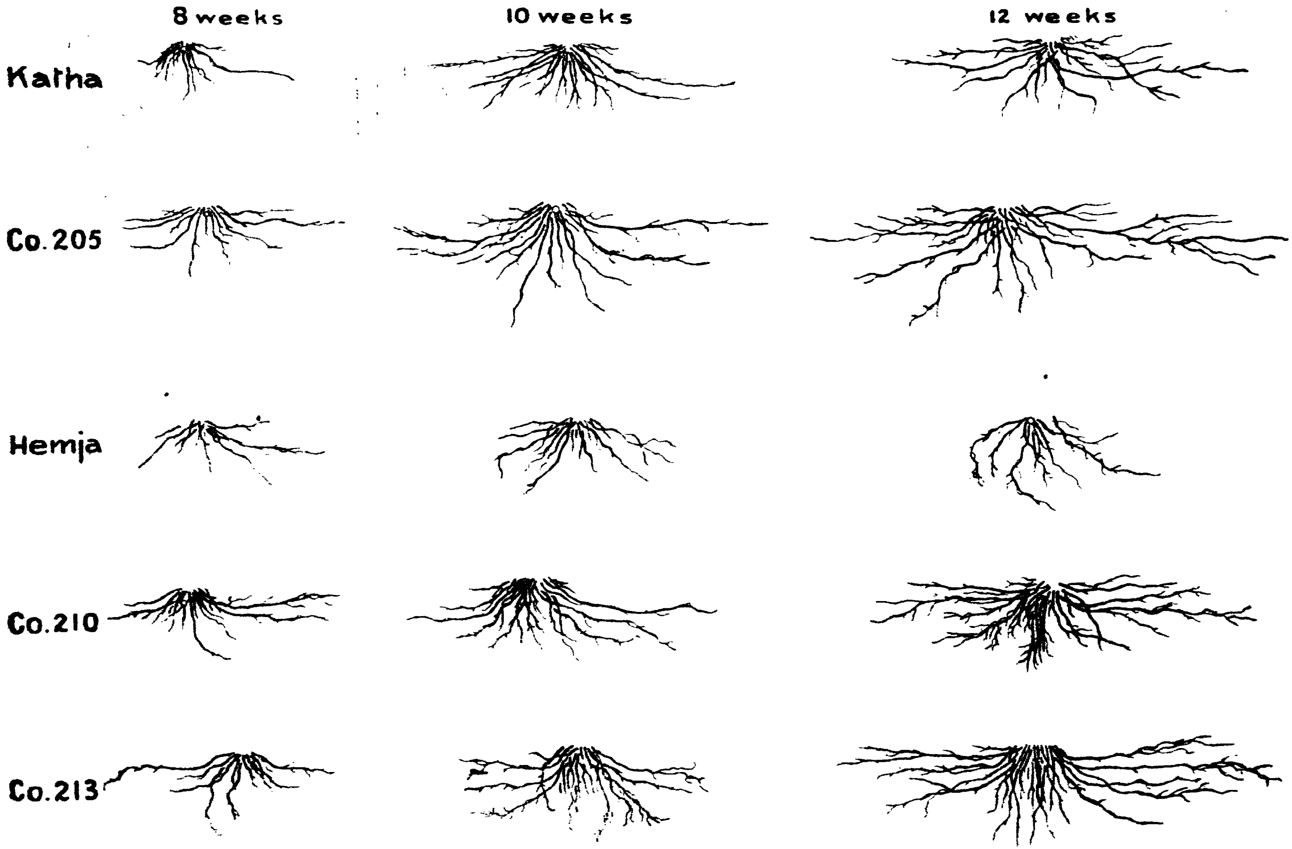
(*e*) *General remarks.*

A medium cane of satisfactory vigour and good habit.

PLATE VIII.



Root Systems of Certain Coimbatore Seedlings.
(as compared with those of the indigenous varieties)



Katha is an indigenous cane of the Punjab and Hemja oi Bihar.

V. Root studies.

It is only in recent years that root systems of plants have been receiving some attention. Man acts on a crop mainly through the soil and hence through the roots. Knowledge of the nature, depth and mode of development of the roots at different stages of growth and under different conditions, is of considerable use in forming ideas about the suitability or otherwise of a seedling to a given locality. It needs to be mentioned here, however, that the study of root systems is more difficult and considerably more laborious than that of the usual morphological characters.

Certain of the Coimbatore canes have been under study for their roots both at Coimbatore and elsewhere for some time. The better performance and hence the popularity of these seedlings would appear to have resulted largely from their possessing a root system superior to that of the indigenous varieties. (Pl. IX.)

In the subsequent paragraphs the roots of certain of the seedlings are described in some detail. These are based on a large number of field dissections and on data from plants grown in a manner specially designed for such studies.[1] The cane produces two classes of roots, *viz.*, (1) *set roots* which are produced soon after planting from the incipient root tips found at the base of every joint, and (2) *shoot roots* which are produced at a later stage from the developing shoots.

(*a*) Co. 205.

Set roots. These roots develop latest in this cane. A fair number of the resting root tips do not take part in the first flush, but produce roots later on should a need arise. This would appear to be a valuable and definite provision against adverse conditions during the earlier stages of growth. These are distinctly thinner at origin and, under field conditions, function for a much longer period than in the case of the other seedlings.

Shoot roots. These develop much later than in the other canes and are less in quantity during the early stages. This is interestingly correlated with the poorer vegetative vigour of this seedling up to a period of three to four months. The cane developes remarkably and almost suddenly after this period.

The one striking feature about the root system of this cane is the great depth of soil which it is able to tap. Even under unfavourable conditions the roots have been traced to depths of over nine feet at Coi ubatore.

(*b*) Co.'s 210 and 213.

Set roots. These develop earlier than in Co. 205, most of the resting root tips taking part in the process. These are of uniform thickness throughout their length and perish almost immediately after the development of shoot roots.

Shoot roots. These develop earlier than in Co. 205 and in greater quantity even from the commencement.

[1] Venkatraman, T. S. Simple contrivances for studying Root Development in Agricultural Crops. *Agri. Jour. India*, Vol. XIX, Part V, p. 509.

Roots of Co. 210 take more kindly to stiff soils than those of Co. 213. In sandy soils roots of Co. 213 go deeper than those of Co. 210.

(c) Co.'s 214 AND 223.

These two seedlings have not yet been studied in detail. *Set roots* develop earliest in these two canes, almost all the resting tips taking part in the process.

THE FUNCTION OF THE ANTERIOR TIBIAL SPURS IN *AMSACTA ALBISTRIGA*.*

BY

Y. RAMACHANDRA RAO, M.A., F.E.S.,
Acting Government Entomologist, Coimbatore.

AMSACTA—AS A PEST.

Amsacta albistriga—the red Hairy Caterpillar—is a serious pest of various crops—especially groundnut and *cumbu* (*bajri—Pennisetum typhoideum*) in South India. It usually appears in millions and in its later stages marches in armies from field to field and causes a wholesale destruction of crops.

When full-fed, the caterpillar enters the soil and, burrowing down to a depth of 5 to 9 inches, prepares an oval chamber, lines it with silk and hairs and transforms inside into a pupa. The insect remains in the pupal state till the first rains of the following monsoon, which in South Arcot are received in June-July. Then it gradually transforms into the moth and awaits a fairly soaking rain to enable it to work its way to the surface. A heavy emergence of moths may usually be expected within 48 hours of a heavy shower. The moths mate and eggs may be laid on the very night of emergence. Each moth can lay on the average about 1,000 eggs.

Taking advantage of the fact that moths emerge in large numbers at one time and can easily be collected, hand-picking of moths has been advocated as a preventive measure for this serious pest. It was first tried with success in Mysore in 1910 and has since then been adopted there with successful results. In the Madras Presidency it has been under trial since 1922 and promises great success.

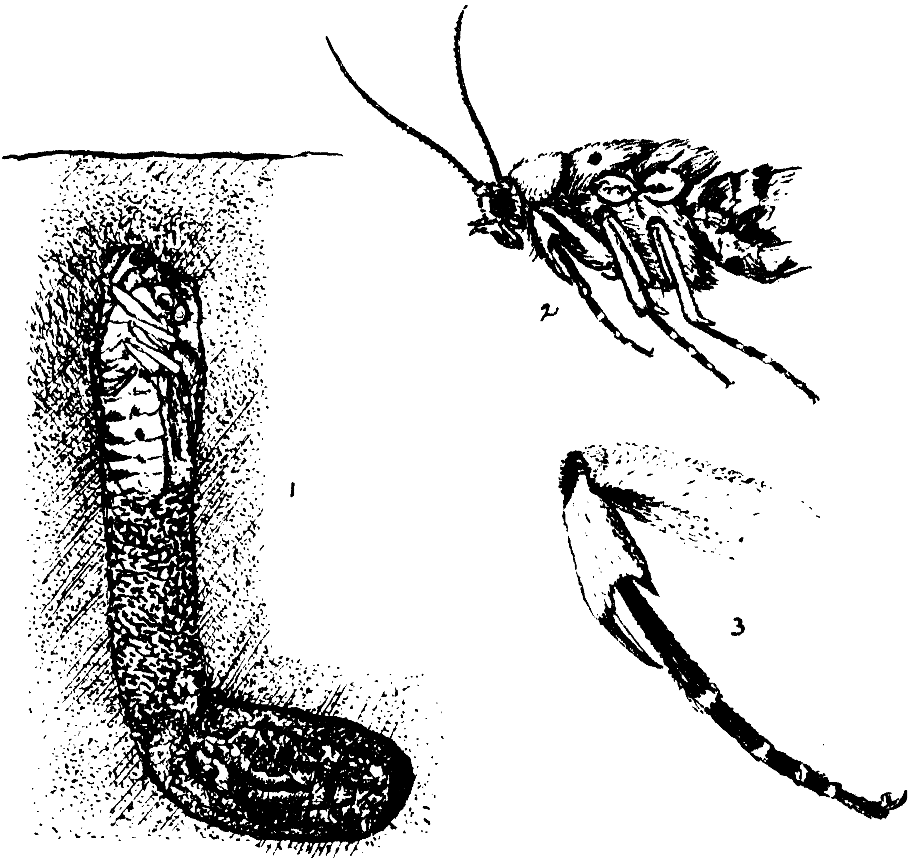
HOW THE MOTH EMERGES FROM THE SOIL.

The great features in the life-history of the pest, however, are its life of concealment in the soil for nearly 10 months in the year and its powers of emergence as moths at the right time during the next season.

Taking into account the fact that the pupæ are situated at a depth of 5 to 9 inches in the soil, it struck the writer as rather wonderful that the moths—frail objects as they are—should be able to find their way to the surface of the soil from such a depth. During a recent visit to Maligampattu in S. Arcot, where hand-picking of moths was being demonstrated, the soil from which moths had been reported to have emerged was carefully examined. The soil certainly appeared as if it had been riddled, the holes being about ¼ inch in diameter. On examination,

* Paper read at the Indian Science Congress, Lahore, 1927.

however, each hole was only about ½ inch deep and appeared to end blindly. A careful sectioning of the sides of the holes gave no indication of the tunnel which the moth might be supposed to have burrowed out of the soil on its way up from the pupal chamber. It was evident that the tunnel must have been blocked up behind as the moth progressed upwards.



Amsacta albistriga.

Fig. 1. Moth using the tibial spur in working its way up to the surface of the soil.
Fig. 2. Lateral view of the moth with the anterior tibial spur.
Fig. 3. Enlarged view of anterior tibia and tibial spur.

THE ANTERIOR TIBIAL SPURS.

A casual examination of the moths collected in the field at that time revealed the existence of a remarkable structure in their front legs. A strongly chitinised expansion was found at the distal end of the anterior tibiæ. The anterior tibia was very short and thickset, and was flattened distally. It terminated in two sharp spiny expansions, the exterior one being small and the interior nearly as long as the

tibia, curved and somewhat sabre-shaped. It was altogether a formidable structure, the usefulness of which to the adult insect did not appear to be very clear; but there was no doubt that it was a normal structure since it was present in all the specimens examined. Moths just emerged from the soil and pupæ in which the moths were ready to come out were next examined and were found to have it in all cases. The possibility that the object of this structure might be to aid the moth to dig its way to the surface of the soil, was then considered and observations made to test the correctness of that view.

Some of the pupæ wherein moths were ready to emerge were kept in tubes under a depth of about 4 inches of loose moistened soil in order to observe how the moths were able to make their way out of the soil in nature. The moth was first seen to break its way out of the pupal shell and to wriggle out into the soil. It then made use of the spurs on the anterior legs as showels to clear a space above its head, and the soil particles as they were loosened out by the spurs were swept and pushed down by the movement of the other legs until they were consolidated below by the wriggling contortions of the soft abdomen. As the showels were used and the digging progressed the insect was found to turn round and round so as to produce a tunnel of even width. · It was easy to see that in this way the moth would naturally obliterate all traces of the tunnel it had made as it progressed upwards towards the soil surface, and the shallow depth of the holes found riddling the soil at Maligampattu was thus easily explainable. After emerging from the soil, the moths climbed up any tall plant near by and took rest after voiding their excrement. It was at this time that the wing rudiments became elongated and developed into wings. In these experiments only loose sandy soil was used and the moths took from 15 to 20 minutes to traverse 3 to 4 inches of soil. It is not possible to say how long they would actually take to force their way up to the surface under natural conditions, but since there is a definite interval of 40 to 48 hours between a soaking rain and an emergence, the moths probably take several hours to find their way out of the soil.

Such spur-shaped tibiæ are also noticeable in *Estigmene lactinea* in which species also the caterpillars burrow into the soil for pupation, while they are absent in *Pericallia ricini* where the cocoons are formed either on plants or on the walls and roofs of houses.

These spurs would, obviously, be ineffective in a clayey soil owing to its sticky nature when wet, and this probably explains why the *Amsacta* pest thrives only in loose red loam soils.

NOTE.—Since writing this note, I have been informed by Dr. K. Kunhikannan, M.A., Ph.D., Entomologist, Bangalore—to whom I had sent a copy for favour of criticism—that he had noted this structure and had made similar observations on its function as early as fourteen years ago, but had put off publishing them. He confirms most of my observations. [Y. R. R.]

SELECTED ARTICLES

THE RAISING OF SEEDLING CANES IN JAVA*.

WHEN the fertility of the seed of the sugarcane was finally demonstrated and generally accepted, a good deal of attention was devoted to it in Java, but it was regarded rather as an interesting scientific fact than as of immediate practical use. But this study proved to be of the utmost importance when, shortly afterwards, the industry was threatened by the disastrous outbreak of *sereh* disease in the cane fields. It was an easy matter to concentrate attention on the raising of seedlings, for the purpose of obtaining new varieties which were resistant or immune to this disease. This work was carried out on the experimental station at Pasoeroean, and the immediate results are known to all. Seedling work, although varying in its prominence at different periods, has been continued ever since ; as it was recognized once for all, that it was a legitimate and fertile means for improving the character of the canes being grown. Although often receiving little attention from the outside world, the botanists of Java have gone on steadily with the work to the present day, always with the idea of obtaining better and yet better varieties for the local conditions. Java seedlings have spread over every part of the world, those already waning in their popularity in Java being often used elsewhere with advantage. These facts make it important that more should be known about the methods employed, the *raison d'etre* of the various seedlings sent out, and especially the lines of development in the Java work. This work, controlled as it is by the planters, is of course eminently practical, but nowhere else is it based on such careful preliminary scientific study. Whether relying on the fact that the local conditions are entirely peculiar, or influenced by the little known language in which the results were from time to time published, comparatively little is really known of the inner details of the Java work, and the difficulties which have been met and surmounted.

The colossal task of writing up the plan and results of each year's work from the start has now been successfully accomplished by J. P. Bannier, a plant expert attached to the Pasoeroean station, and he has published the account in the *Archief.* [1] As, besides the language difficulty, this paper may not be available to many readers of this Journal, the following article has been prepared for the benefit of those who may be interested in the important subject. It will not be possible to treat of all the subjects discussed, for Bannier's paper is very comprehensive and extends

* Reprinted from *Int. Sugar. Jour.*, XXIX, No. 337.

[1] *Med. van het Proefstation*, Jaargang 1926, No. 19.

roughly to 60 pages of illustrated letter press and 80 pages of tables. It is divided into three sections: (1) Methods of raising and selecting seedlings, (2) The line of work and technique at Pasoeroean, and (3) The results obtained from 1893 to 1925. The first of these sections is dealt with in this number of the Journal.

Flowering and Crossing.

The crossing programme. The raising of cane seedlings is an extremely easy matter, and it is a constant source of surprise, to those engaged in the work, that the idea ever crept in that the sugarcane was infertile. The author states that the methods employed have undergone little change during the past fifty years at Pasoeroean, although some minor simplifications and improvements have from time to time occurred. These methods were fully described in 1910 by Willbrink and Ledeboer[1], and they are unaltered at the present time. Greater and greater attention is, however, being given to the parents, and here the main difficulty is met with. Many workers have wondered why it has been so difficult to apply ordinary Mendelian principles to the sugarcane; but it is increasingly evident that the make up of the raw material, the cultivated plant, is far more complicated than in most other cultivated forms. The sugarcane has, in fact, been subjected, during its long course of cultivation, to an extraordinary amount of hybridization.

Every year the parents to be used in the campaign are carefully discussed beforehand, with special reference to the needs of the industry. They are then studied afresh in every direction. The parents usually include both superior and inferior kinds, all of which are chosen for the transmission of some desired character. Selfing is no longer practised, as the almost universal result is a collection of types inferior to the parent. One especially important point to determine is which characters are usually passed on by a parent to its offspring: and here the complex nature of the sugarcane is particularly discouraging. Some varieties have been found to pass on good qualities, and others not, while new good characters appear to arise from the chance meeting of hidden inherent factors. The method of crossing a plant with a great number of others to determine its make up, so often made use of, has been found to be largely inapplicable to the sugarcane.

The flower. The first point to determine is which kinds will flower together. Canes about to flower can be easily picked out, by changes in the terminal shoot some time before anthesis, and four stages are described, from the first lengthening of the upper internodes to the bursting of the floral sheath. These stages are always noted on the cane varieties growing, and recorded for future use. The flowering season at Pasoeroean extends from the latter half of March to the end of May, but the exact time for any kind varies greatly in different places, and from year to year, owing to soil and climatic conditions, at present only partially understood. There is a constant tendency for Glagah (*Saccharum spontaneum*), and Kassoer and its descendants, to flower early; while the better kinds are some three weeks later. This is a great bar to many desired crosses; but this difficulty has been largely

[1] *Archief*, 1911, I, p. 367.

overcome by transferring the crossing work to the Malang plateau, some 1,200 to 1,600 ft. higher, with better rainfall and lower temperature. Here the time of flowering in the different kinds shows a tendency to overlap, some kinds continuing to flower for 1½ to 2 months; while others which do not flower in the plains, such as Lahaina, Zwinga, Badila, Cayana, Uba, do so freely on the plateau. A great mass of data on this subject has been accumulated, which it is impossible to reproduce; but, in a Table, details concerning some of the less known forms are given; the amount of flowering, the part of the season, and the relative fertility of male and female organs.

Use as mother or father. The species of *Saccharum* are usually bisexual, but in many kinds of sugarcane the pollen is more or less infertile. If this were not the case, crossing would only be possible by removing the stamens before pollination. This method has been explored sufficiently to show that it is either inpracticable or that the results are entirely out of proportion to the amount of labour expended. The degree of male sterility in a given variety is, however, not constant, but is greatly influenced by the monsoon; and, even in the same season, there may be considerable differences. The method used at Pasoeroean for determining the viability of the pollen is still based upon the observation, made long ago, that fertile pollen grains have abundance of starch, while this substance is absent from the infertile ones. The iodine test for starch is therefore relied on. The percentage of fertile pollen is then gauged and, when this is lower than 40, the danger of foreign pollination is considered to be acute. In such circumstances, caging is thought to be necessary. The father and mother are chosen according to the amount of fertile pollen normally present—the mother little or none, the father an abundance.

Crossing. Four different methods are employed at the station, and these may be briefly termed, free, cage, living, and artificial.

(1) *Free crossing* is by far commonest at present, having to all intents and purposes completely replaced the formerly used cage. It consists in bringing the male arrows to the female daily, and placing them in such a position that the greatest amount of pollen shall fall directly upon the receptive stigmas. The female-arrow is firmly fixed to a bamboo support, and the males are so placed that they completely surround the female, thus protecting the latter from the entry of any pollen from other plants. To ensure the freshness of the male arrows, they are cut with five or six joints attached, and placed in a bamboo filled with water, which is fixed to an upright stake. Flowering proceeds from the top of the arrow downwards and the part of the arrow which flowers most profusely is from half to three-quarters down. The male arrows are cut when the flowers are open in this region, and they are placed so that these open flowers are just above the part of the female arrow which is then in flower. The time taken by an arrow for all the flowers to open is from six to seven days, although variations occur.

(2) *Crossing in cages.* These are, as usual, cylindrical, and consist of fine muslin tightly wound round a bamboo frame. They are hung up so as to enclose the female

arrows, on a gallows-like support, and can be freely moved up and down. The male arrows are obtained and treated in exactly the same way as in free crossing. The cage method is condemned in Java, as requiring too much work for a large programme to be carried through in a limited time ; and also because it is considered to be much less fruitful in results, due to the absence of free air, and the greater temperature inside the cage. It is only used in Java where, for scientific reasons, it is imperative that foreign pollen should be excluded.

(3) *Living crossing* is the term applied to those canes in which both male and female arrows remain attached to their parent stems, the male arrow being bent to the appropriate position as regards the female. Both are firmly fixed and the male requires some propping. The main advantage of the method lies in the saving of male arrows ; but it requires the planting of the selected varieties close together, and there is always the chance that one or other may not flower. When it is convenient, two male arrows are used, for the greater protection from undesired pollination. It is only used on the station when, through accidental circumstances, it is desirable and possible ; the method at present is less employed than any of the others.

(4) *Artificial crossing.* Collecting the pollen from the male plant, carrying it to the female and applying it to the stigmas. Both male and female arrows are firmly fixed, and the pollen is collected between 6 and 7 A.M., when it is most freely produced. The method is as follows : The pollen is collected by placing a thin, shining, dark blue or black piece of cardboard under the male arrow ; shaking the latter gently and brushing the pollen to the middle ; then folding the cardboard tightly and carrying it to the female arrow ; here it is carefully brushed on to the part which is in flower. The female arrow appears to be unprotected in any way ; but the danger of unwished for crossing is largely eliminated by only using the method at the end of the season, when arrows are scarce. The advantage lies in the fact that one male arrow can be made to serve for the pollination of a number of female.

Crossing must not be attempted at all times of the day. The flowers open shortly after sunrise, and the anthers a little later. During the early morning hours, the whole atmosphere is full of fresh floating pollen. Towards mid-day pollination diminishes, and by 3 and 4 o'clock has practically ceased. The male arrows are cut between 3 and 5 o'clock in the afternoon, and are at once placed in their bamboos, and arranged around the female arrow. The only exception is in artificial pollination, which must be done when the anthers are producing their maximum amount of pollen.

Ripening the seed and sowing. As soon as all the flowers have opened in the female arrow, the males are withdrawn and thrown away. A cage is then placed over it to protect it from birds, and from the chance of the seed becoming mixed by the blowing about of parts of ripe arrows in neighbouring plants. Ripening takes from three to four weeks, longer in Malang than in the plains, and there are certain sure

signs when it is completed. The smallest portions of the arrow begin to fall apart, and the small leaflet under it dries up. Then the arrow, which has all along been attached to the parent plant, is cut off short below the cage and carried to a sheltered spot to dry for a few days, fully exposed to sun and air, but carefully shielded from possible rain. When dry, the arrow readily breaks up, and its fluffy parts are collected in a beaker : they may, if desired, be sown without more ado.

Sowing is done in wooden trays whose bottoms are pierced with holes for drainage, 50 cm. long and broad, and 15 deep ; and these are arranged many together upon bamboo racks, so as to be readily inspected and manipulated. The soil is a finely sifted mixture of fertile earth (zavelgrond, " tarapan "), sand, and cattle manure, in equal parts. For proper mixing all must be quite dry and finely divided, the manure being beaten with bamboo sticks to divide it up. The fluff is evenly spread by hand in a thin layer and firmly pressed down, then lightly covered with earth to keep it in place. Every precaution must, in fact, be taken to prevent the light particles from blowing from one tray to another. For this purpose, the sowing is done under a special cover, and the whole tray is at first kept tightly closed with a wire and cotton frame. Watering, which helps to fix the fluff, is done with a very fine rose, and afterwards regularly twice a day. During the hottest part of the day (between 11 and 3) the trays are protected from the sun, but otherwise full sun and air are allowed. Rain is guarded against by special bamboo screens.

Germination. This takes place early in Pasoeroean, usually on the afternoon of the third day ; and if, after 10 days, no seedlings have emerged, the tray is discarded, as there is then no prospect of germination. One crossing may give many more seedlings than another ; some yield 5-10 per tray, while others will furnish hundreds or even thousands. 100 POJ and 2883POJ may be quoted as examples of varieties with few seedlings. Occasionally, patches of seedlings die away, through fungus attack. In such cases, the best plan is to remove the healthy sections to a fresh tray, taking care to avoid root injury by including clods of earth. Spraying with pyoctanin solution has been found effective for checking the attack.

Raising the seedlings. The young plants of the sugarcane grow very quickly, and the root system is sufficiently developed in three to four weeks, for them to be planted in pots. A single arrow may produce several thousand seedlings, many of which may be of value, but it is obviously impossible to grow them all to maturity. It is usual to take 200 from one combination of parents, if there are several trays of one combination 150 of each, but with poor germination rarely over 100. The choice of parents is a dominating factor, and it has been found that, if the results of a cross are poor, a repetition rarely produces anything of value. In potting up, the seedlings are not selected in any way ; they are just taken casually, each if possible with a small clod of earth attached. The pots are about 5 in. in diam. at the top, and are filled with the same soil mixture as the trays. They are well watered, and kept in a shed for a couple of days, after which they may be safely brought out into the full sun. As before, they are watered twice daily, and in about two months

the seedlings will be about a foot high, sprouting will have commenced, and they are ready for planting out.

The nursery. This is divided into plots, each of which is completely surrounded by a drain. The plots are long, and each is divided by a pathway down its length, for inspection purposes, into two beds. Furrows are drawn across the beds, one *roe* * long and 3½ ft. apart; there are about 70—100 furrows in the plot, and each furrow will contain seven seedlings. In planting, all of the earth in the plot is turned out, the roots binding it together; this is placed in the furrow and plentifully watered. The roots, somewhat cramped by the pots, now grow rapidly, and the improvement in the seedlings during the first week is astonishing; failures rarely occur at this stage. The plants are now subjected to ordinary field conditions, with the exception that only two-thirds of the usual dose of ammonium sulphate is administered. The object of this is to emphasize of the differences in growth; for a poor plant will respond to good manuring, and differences will be diminished. The whole period of growth, from the fertilization of the flower to the maturing seedling, is roughly about 14-15 months.

SELECTION.

In practising selection of seedlings, three things have to be considered: At which period of growth it should take place, what soil is best for the nursery and what standard should be maintained; or, briefly, when, where and how to select.

When to select. The earlier practice was to pick out the promising seedlings from the trays for potting. This, however, is now considered of little use, if not dangerous. Many growth characters have not as yet developed and, more important still, the vigour of such seedlings as those of Glagah, Kassoer and its descendants, is often associated with poor juice. Selection is now delayed till the last moment, when full growth has been attained, the best time being in May or June, after flowering. At the same time, it is of some assistance to make careful notes immediately before flowering, for then the canes in the field are covered with dead leaves, with fresh, green tufts above.

Where to select. Light or good soil should be avoided, because here the growth conditions tend to the optimal. In porous soil, plants with weak root systems often show up as if they have strong roots; and in light soils the plants look handsomer than they would do in heavy. In good soil too, many plants would be selected which ought not, in that they would fail in poor soil; and the aim is rather to obtain seedling varieties which do well under as many different conditions as possible, some of these being poor. In a similar manner, but to a less extent, it is necessary to guard against mistakes from placing the nursery in heavy soil, for plants would be selected which, in better soil, might be pithy or might lodge. Nevertheless, the percentage of seedlings selected, which will make good, is usually greater when the nursery is on heavy soil than on light, probably because they possess a stronger root system. From which it may be concluded that land chosen for a nursery should be

* Roe = about 4 yards.

of an average character, if anything, tending to be on the poor side. Yet one other point should be kept in view, and that is the effect of natural selection in the nursery. Nature exercises little selection when the conditions of soil and climate are optimal, and many seedlings will then appear to be worth retaining. In somewhat adverse circumstance, nature itself acts much more decisively, and fewer mistakes are made because of this assistance.

How to select. To maintain a high standard, it is necessary to keep down the numbers of seedlings at all stages, because of the very careful study required for a successful issue. Furthermore, with experience, new characters are constantly being added, on which to base the selections ; and thus the percentages of rejections tend to increase. This is well shown in a statement of the annual percentages of seedlings passed at the end of the first year, during the period 1911 to 1925. For simplification, the five three-year averages have been calculated, and these are as follows : 13·06, 2·74, 1·40, 1·10, 0·54 per cent. From these figures, it will be obvious that the selection during the first year's growth has become very strict and it is followed, as will be seen later, by even more rigorous selection in the second and third years. This explains why so few of the multitude of seedlings grown to maturity (392,871 from 1893 to 1925) have ever reached the stage of distribution to the planters, and, *pari passu*, the very great success which these have met with in the field.

One of the most striking characters among cane seedlings is the very great variation even among those derived from the same parentage. No two in fact are ever alike. But the number of visible differences, on which classification is built up, is alone very great, and, if an attempt is made to enquire into the number of factors involved, it soon becomes evident that the chance of two entirely similar plants ever arising in the plots is extremely remote. Cytological studies show that the sugarcane is much more complicated in its inherent structure than other plants under cultivation. One result of this is that the raising of cane seedlings is peculiarly fascinating because, with a considered choice of parents, any individual seedling may turn out to be of great commercial value.

The first year's selection. The criteria used are largely those included under the general term " habit," and the character of the juice becomes important at a much later stage. Most of the habit characters are observed in the plots before the canes are cut, namely, in May or June. It is, however, important to remember that growth varies from year to year according to the character of the season ; and thus there are no absolute standards, although, in general, certain lower limits are usually fixed. The object therefore is to be content at first with picking out the best that there are, rather than to compare the seedlings with the standard canes. There are very many characters which combine to form the habit of the cane plant, some of which can be easily specified and observed, while others cannot well be put down in writing. Of the former, some dozen or more are briefly considered by the author and a few items are here extracted. For convenience, the word " batch " is used to indicate any collection of seedlings obtained from one crossing experiment.

Length of cane is of course important, and is fairly constant in any batch of seedlings ; but the longest are preferred, other things being equal. If below a minimum, the whole batch is discarded. Distinction should be made between canes that have flowered and such as have not ; the standard for the former is higher, because the part under the arrow is thinner and more or less pithy and devoid of juice, tending to lighter weight. Thickness must be taken together with tillering power, since a greater tonnage may be obtained from a thin, branching variety than a thick one with few canes. A minimum thickness is easy to fix, but a maximum is more difficult. As the result of many years' experience, however, very thick canes are regarded as liable to be inferior or spongy and those of medium thickness are generally preferred. Very great tillering is usually combined with a number of undesirable characters. Further, a seedling in the first year sometimes tillers enormously, but when planted from sets loses this character, while in some seedlings the converse is the case. Therefore, seedlings with only two or three canes should not be rejected on this account alone. Certain batches show a marked tendency to the formation of water shoots, late canes of abnormal thickness. These should be rejected, unless a number of desirable characters are also present.

The form of the cane varies very greatly, but regular, upright ones are preferred, in that they are stronger and have more silica in their walls, to zigzag or crooked ones or those of varying thickness in different parts. Where flowering occurs, the upper part of the cane often becomes thinner, but in some kinds the average is well maintained to close under the arrow. Seedlings with slanting canes are avoided because of the danger of lodging ; with only moderate manuring, they should be erect. Long jointed canes are preferred, but too great length is a disadvantage, especially in thin canes, as the strongest part of the cane lies in the nodes. Straight-sided joints are the strongest and, of the rest, those which widen upwards are the weakest. Thick, swollen nodes are undesirable, and such canes as have many splits (groeibarsten) should be rejected. In many seedlings the root eyes tend to protrude early. If inherent, this should be a definite bar ; but it may depend upon whether the canes are free-stripping. When they are not, insect enemies find shelter, water collects and fungus disease is likely to prevail ; besides which, additional labour is needed for stripping at harvest.

In many batches, the buds tend to protrude from the stem, especially when they are long, and this courts damage, especially in the handling of the sets. Shooting at the top characterizes many flowering canes, but it is also present in others, and is of course undesirable. The form, colour and position taken up by the leaves are of considerable importance. Broad leaves, widely spreading, are preferable to narrow erect ones, for metabolic reasons. Spreading leaves get much more direct sunlight. On the whole, dark green leaves are preferable to lighter or yellowish green ones. Abundant flowering, although in some varieties little is lost thereby, is generally disliked ; this will depend on the amount of pithiness of the parts below, but some material is used up in the formation of the flowers, and non-flowering canes have a

longer growing period. Lastly, evenness of the clump is of great importance. This is greatly affected by the date at which tillering commences, but this is better judged in suceeding years. Unevenness of the thickness of individual canes is often noteworthy in first year's seedlings, but this tends to become less marked, when they are planted from sets. If the differences are very great, however, the seedlings are rejected.

Every seedling grown to maturity is ticketed with a number, and the year of crossing is marked by a letter. These are retained throughout the period of selection, and correspond with a register, giving details of parentage and treatment. When the selection for habit has been made, each plant is dug out whole and taken to the factory. Here, after the tops and waste leaves have been cleared away, a second selection is made, because the underground parts are now revealed and a better idea of the stand of canes can be obtained; a great many rejections take place at this stage. Then the canes are cut off and divided into two parts, the upper third being kept for possible planting for the second year, and the lower two-thirds being passed through the sample mill. The cutting is done with a very sharp knife, in that the internal character of the cane can now be observed, especially as regards evenness of texture, hollows and pithiness, and general soundness. Then the juice is tested, but only as far as Brix and polariscope reading; any attempt to judge the "rendement" would be futile, and this is left till much later. In judging the juice, the standard is again not fixed, but varies according to the general growth and seasonal conditions of the year. The factory results are then combined with those in the field, and a balance is struck for every seedling. As a general rule, although not universally, the handsomest seedlings produce the poorest juice.

The second year's selection. The nursery in which the selected seedlings are planted is laid much as in the first year, with the difference, of course, that a number of plants of the same strain are now found together. The quantity of seed is limited, and the quality often poor, because of flowering so that it is sometimes difficult to fill one furrow (one *roe* in length). If wide planting is resorted to, this must be allowed for in harvesting. Some two or three kinds generally stand out in the first year as particularly promising, though there are not usually more than five which can be so distinguished. The sets for the second year's nursery are called "élite bibit," and the few outstanding kinds are termed "maximalisten." Where possible, sets of the latter are also planted in another place purely for the purpose of multiplication. The method, first adopted in 1918 with 2714 and 2725 POJ, appears to be as follows: Shoots about 2½ months old are able to produce their own roots and therefore can be planted; when this is done young plants are growing which also produce shoots, and these are detached and planted as soon as they are old enough. Thus a nursery of plants of varying age is established, and multiplication is very rapid. The method is termed "seblangen" and, incidentally, gives a good deal of information as to the growth capacity of a kind. A cane which "seblangs" well, is one of

rapid development and strong rooting powers, especially when planted from the upper portions of the cane, and such a kind is usually called a strong one by the planters.

During the 2nd year, because of the greater number of plants, it is possible to distinguish between accidental and permanent characters, and for this reason a number of forms are discarded in which the character in the seedlings proves to be transitory. The true amount of tillering and flowering is also more readily estimated. Then, germination of the set and early growth can be studied, and it is possible to form an opinion of these characters within the first two months. Shortly before flowering, *i.e.*, in February, the general characters of growth and of the leafy crown are well seen, and these are noted ; and the third and last selection for habit follows in May, after flowering. The same characters are studied in the second year as were in the first. For juice analysis, 10 canes are marked for the mill, about the middle of May, in each kind ; good, poor and medium being included. The analysis of these is done twice, namely in June and July, so as to obtain information as to early and late ripeners, five whole canes being used on each occasion. The final selection of the year is made after the second analysis, and the total number of survivals rarely exceeds one quarter of those chosen in the first year. All of the canes are analysed in the second year, in spite of any rejections during the year, in order to obtain general criteria regarding all of those selected in the first year. If any of the " maximalisten " give promise of being better than the standard canes grown, steps are taken to multiply them as rapidly as possible, so that plantations may be able to obtain seed early, if they wish to. As an example of the results obtained by the method (already described), 2878 POJ may be cited ; in 1922 there was one full grown plant, in 1925 there were 1.750 bouws, and in 1926 about 25,000 under this variety.

The third year's selection. The seedlings are planted now in a greater number of furrows, usually 2-10 : and the furrows extend right across the plot, so as to be on both sides of the pathway. The plants on the two sides receive different amounts of ammonium sulphate, one the same as in the first and second year, and one half as much. The idea here is to obtain information as to how the seedling will behave under better and worse conditions ; but it is confessed that the method has not as yet given very definite results. The principles of selection are similar to those in the second year, and 10 canes are crushed of each variety on each side of the path. Until the end of the third year, each kind retains its original first year number, but those few which survive at the end of the third year enter the list of POJ canes. Further testing now takes place on the plantations, in order to compare the new seedling canes with those being grown. After a 30-fold harvest made in this manner, it is considered possible to judge, with reasonable certainty, what importance a seedling has for the industry at large.

(To be continued.)

C.A.B.

CO-OPERATIVE SOCIETIES AND SOME OF THEIR DIFFICULTIES.

BY

TOM LEWIS.

URBAN societies for the purpose of trading on co-operative lines have been in existence for a considerable time, but it is only within the last few years that anything of a real practical nature has been attempted in this country so far as agricultural organization and co-operation is concerned. While the British workmen have always been the foremost in this movement, the British farmer has in the past been inclined to look upon this idea of combined trading with a certain amount of suspicion and distrust. This reluctance on the part of the farming class to join co-operative societies has proved disastrous to them in some respects, in that it has enabled the foreign farmer who has thoroughly imbibed the spirit of combination to secure markets for their produce in competition with the English growers.

Although progress has been slow, there are abundant signs that some headway is being made and throughout the United Kingdom we have to-day a number of societies which are doing excellent work. Unfortunately this is not true of all of them and it is the purpose of this essay to enumerate a few of the difficulties which militate against their success and these will be commented on briefly in the following order :—

(*a*) Insufficient investigation previous to forming a society.
(*b*) Inadequate finances.
(*c*) Inefficient management.
(*d*) Lack of support on the part of the members.
(*e*) Price policy.
(*f*) Lack of co-operation between societies.

(*a*) *Insufficient investigation previous to forming a society.* It may be fairly easy to persuade farmers in a district to start a society by quoting examples of successful co-operation in other counties where success is due to conditions quite inapplicable to local circumstances. To be successful a society must perform a definite function and meet a particular need. These services are of two kinds—the purchase of farmers' requisites and the sale of farm produce.

A society should start with the simplest form of co-operative effort and then develop on broader lines when its financial position is more stable, and when it has

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[1]Reprinted from *Jour. Uni. College of Wales*, Vol. XVI.

gained for itself a firm hold on the trade of a district. In the case of a requisites society the service will take the form of improving and guaranteeing the quality of requisites and in reducing prices or keeping them from rising. In performing this work the society will be faced with keen competition from outside, and it must also be prepared to give farmers some of the long term credit to which they have been accustomed.

On the other hand the problems of a farm produce society are more intricate. In the case of sale of produce societies, it is quite apparent that the need for investigation is an absolute necessity. The crown of success in these, lies in the power to make prompt payment and in a guarantee of regular supplies of a st ndard quality. To sell well, a society must be able to build up a reputation for regular supplies of standard quality. Further, the collective sale of various commodities involves large expenditure as to buildings, plant, etc., and consequently a large turn-over is essential and this necessitates a liberal supply of capital and the constant loyalty of farmers in maintaining a high standard of produce.

(b) *Inadequate finances.* Many societies have been formed without sufficient capital and they have either failed or their progress has been retarded. It cannot be too strongly emphasized that one of the most important factors essential to the success of a society is that it should be adequately capitalized and each member should take upon himself to supply at least sufficient funds to finance his own business through the society. It is essential that increase in membership and turnover should be accompanied by an increase in capital. Lack of capital is often responsible for failures in private firms. joint stock companies as well as co-operative societies, but the effects of failure in the case of the latter are more keenly felt than in the case of joint stock companies since their liability is usually spread over a large number of scattered shareholders. A joint stock company can appeal to the public by offering higher returns in the form of dividends. But in the case of co-operative societies interest on capital is usually limited to 5 per cent. as it is their object to distribute benefits to members in proportion to their trading with the society and not pay high interest on capital. This means that societies have evidently to be financed by farmers' own capital with the result that many are under-capitalized. Bank overdraft is not a satisfactory means of finance ; it is liable to curtailment at any time and its withdrawal may cause serious inconvenience. Moreover, a high rate of interest must be paid whether the society is operating profitably or not.

(c) *Inefficient management.* Co-operative societies must realize that efficient management is necessary to successful trading. In the past, societies with a few notable exceptions have invariably refused to pay salaries which would attract really proficient managers and undoubtedly many failures are attributable to this shortsighted policy.

The question of the control of managers by committees presents many difficulties. Committees may be composed of members who have very little commer-

cial experience at their call and perhaps but very little interest in the society apart from the safety of their capital. In some cases the problem could be partially solved by the appointment of a small executive committee chosen from the more business-like members of the society.

Successful working, however, depends on the co-operation of committee and manager. The hard work of a good committee may be of little benefit unless backed up by an efficient manager. But a good manager should be given reasonable freedom in conducting the business affairs of this society, and not be unduly tampered with. All that the committee should do is to keep in touch with his work and advise him on matters of general policy ; it is as easy to spoil a good manager by over as by under supervision.

(*d*) *Lack of support on the part of members.* With those who have been advocates of co-operative trading in this country it has been quite common for them to place the lack of support on the part of members as being responsible for the failures of societies. While it is a recognized fact that co-operative methods and combined trading cannot be successful without loyal and unflinching support on the part of members, still when we have badly-managed societies it is hardly to be expected that persons will invest their capital in, and give support to, such undertakings. But given good and efficient management, there is no excuse for disloyalty on the part of members and much of the apathy in the past has been quite unfounded.

(*e*) *Price policy.* The question of what prices to charge to members or what prices to pay for produce is one which has always engaged the attention of co-operators in the past. On the whole farmers in the past have expected a society to be able to sell or buy at prices much more favourable to themselves than is justified by circumstances. It is a well-known commercial axiom that a concern entering a competitive market must gradually strengthen its position, and that those who have invested capital must wait for their benefits and profits. This has been a flagrant cause of failure in societies selling farm produce, notably dairy societies. In order to attract supplies societies have been prone to buy at artificially raised prices without any consideration of the prices at which they can sell or of the costs of handling with the result that disaster is inevitable. The payment of higher prices involves a serious risk to a society unless it is well capitalized and in possession of a great deal of information as to future prices in consuming markets. Farmers must learn to accept current prices less the cost of handling and wait for the extra price in the form of a bonus on supplies at the end of the year.

(*f*) *Lack of co-operation between societies.* This is a problem needing urgent consideration by all societies and the greater the number of societies the more is the necessity for co-ordination. The importance of the problem is not so insistent in the case of requisites societies, yet even with these it would seem that if they are to render the maximum service, there must be bulked purchase by grouped societies. The experience of the past 25 years has shown that especially in the case of produce societies, it is essential that co-operation should have a broad territorial basis.

This is emphasized in the case of dairy produce and egg collecting societies which are competing against each other in the same market. The marketing system can hardly be called efficient when such a state of affairs persists, but attempts at federation in the past have hardly been encouraging.

In conclusion, however, one is inclined to the belief that the future of agricultural co-operation in this country is full of possibilities. Experience in the past has often been bitter, and the problems of the future are likely to be intricate ones which demand determined handling. But the development of agricultural education in our colleges and farm institutes and the extension of such work to the countryside by efficient and tactful organizers is equipping a large group of young farmers for this arduous, yet beneficial, task.

NOTES

A LEAF ADAPTATION CONDUCIVE TO MOSAIC RESISTANCE IN THE SUGARCANE.

THOUGH different views are entertained about the exact nature of the mosaic disease and the actual mode of transmission, there is a general consensus of opinion among cane pathologists that the disease is insect-borne. Assuming this to be so for the moment, it is obvious that any peculiarity in the leaf, rendering it inconvenient or difficult for the insect either to visit it or introduce the virus into the tissues, would conduce to mosaic resistance.

Going through the recorded resistance or susceptibility of the different varieties to mosaic, there is one cane which, at the present time, is widely acknowledged as immune, *viz.*, Kassoer.[1] Even its seedlings have been found to be immune and this immunity is attributed to one of its parents Glagah—a grass which also has been found to be immune.

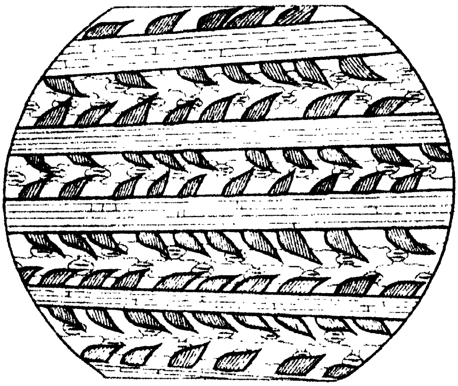

FIG. 1. Glagah.

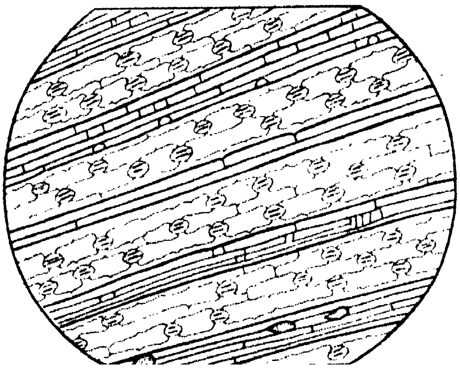

FIG. 2. Striped Cheribon.

Lower surface of leaf × 83⅓.

The leaves of Glagah show on the surface sharp stiff unicellular bristles which, from their position and arrangement, would protect the stomata and the surrounding regions from the attention of insect visitors. In Fig. 1, which is based on a *camera lucida* drawing, the bristles are seen shaded with lines. The leaves of Kassoer show a similar adaptation and the inference is rather attractive that the immunity of Kassoer is probably due to its inheritance of these bristles.

At the other and opposite end, we have the large number of broad and soft leafed varieties, very susceptible to mosaic. A careful examination has shown that

[1] Brandes, E. W. Breeding of disease-resisting sugar plants for America. *The Reference Book of the Sugar Industry of the World,* July, 1925.

these do not either possess the bristles or show them in such small numbers as to be ineffective as a protective arrangement (Fig. 2). Other variations have also been noticed in the number, size, shape, nature and arrangement of the bristles, suggesting an obvious correlation with their efficacy as protection. The susceptible varieties so far examined include :—Poovan, Co. 1, Red Mauritius, Purple Mauritius, Java (Hebbal), D.74, A.2, A.95, B.147, B.254, B.1528, B.6346, B.6388, B.A.6032, B.6308 and Vellai.

Of the wild Saccharums, *Saccharum Narenga* [1] has been found susceptible and it is devoid of the bristles herein mentioned.

The bristles and their arrangement are easily seen in reflected light with a powerful lens. For detailed examination, either thin surface sections may be taken or the leaf thinned down to almost the surface layer, by repeated scrapings from the opposite side with the razor. These bristles are found both in the unrolled leaves and in the leaves which are in the process of rolling out—just the regions now considered to be the first recipients of the insect-borne virus.

The efficacy of the protective arrangement becomes apparent, when it is remembered that the surface of a cane leaf consists of a series of longitudinal ridges formed by the veins, and the stomata are found in a slight depression of the surface in between the veins. The epidermal cells above the veins are thick-walled[2] and are, therefore, perhaps well protected. Dr. Brandes has shown that " with *Aphis maidis* the beak is usually placed on the cuticle covering a stomate guard cell at the point where the cuticle is thinnest and setæ thrust into the latter by pressure."[3] The arrangement of the hairs is such that they would come in between the insect and the vulnerable points on the leaf surface, *viz.*, the stomata.

Other adaptations towards mosaic resistance that have suggested themselves in this work include :—

(*a*) Compactness and rigidity of the leaf tissues, and

(*b*) Presence in the tissues of substances to counteract the virus when introduced.

[T. S. VENKATRAMAN AND R. THOMAS.]

THE TOLERANCE OF NITRIFYING ORGANISMS TO HIGH CONCENTRATIONS OF AMMONIA IN SOIL.

IN his paper on " The effect of varying concentrations of ammonia on the nitrifying power of the soil " (*Agri. Jour. of India*, Vol. XXII, pp. 298-300), the author

[1] Brandes, E. W., and Peter J. Klaphaak. Cultivated and wild hosts of sugarcane or grass mosaic. *Jour. Agri. Research*, Vol. XXIV, No. 3.

[2] Artschwager Ernst. Anatomy of the vegetative organs of sugarcane. *Jour. Agri. Research*, Vol. XXX, No. 3.

[3] Brandes, E. W. Mechanics of inoculation with sugarcane mosaic by insect vectors. *Jour. Agri. Research*, Vol. XXIII, No. 4.

has set about finding a limit of ammonia accumulation tolerated by the nitrifying organisms in the soil, and for his experiments has selected " black cotton soil possessing a very vigorous nitrifying power " ; and has drawn the conclusion " that concentrations of over 100 mg. of ammoniacal nitrogen are definitely injurious to the process of soil nitrification." This conclusion, applicable as it may be to the black cotton soil taken from a cultivated area, cannot, however, be accepted as a general proposition, and which the author is not justified in drawing from his limited experiment on one soil. Probably the conclusion is based on the conception " that nitrifying organisms are unable to thrive in the presence of organic compounds or free ammonia or ammoniacal salts." This conception is based on the experiments of Winogradsky, Omelianski and others. It has, however, been found at Pusa[1] that the tolerance or otherwise of nitrifying organisms in a soil depends on the number of such organisms present in the soil, and that soils vary in their content of nitrifying organisms to a great extent. Certain soils like the garden soil or soils near the manure pits are so very rich in the nitrifying organisms that they are capable of nitrifying large quantities of organic or ammoniacal nitrogen without showing any signs of inhibition of nitrification which is seen with ordinary arable soils if the same quantities of organic or ammoniacal nitrogen are added to them.

Further, it has already been shown that the nitrifying power of a soil could be increased by a process of activating it or increasing the number of nitrifying organisms in it, showing thereby that the tolerance of organic or ammoniacal nitrogen by the nitrifying organisms is rather a question of numbers and not of their physiological activity. Other workers[2] have found that the nitrifying organisms can tolerate ammoniacal and organic nitrogen and are not inhibited in their activity by the presence of these compounds. [N. V. JOSHI.]

MANUFACTURE OF SUGAR DIRECT FROM CANE IN INDIA, 1926-27.

TWENTY-six factories making sugar direct from cane worked in India during the season 1926-27 as against twenty-three in the previous season. Eleven of these are situated in the province of Bihar and Orissa, ten in the United Provinces, two in Bombay Presidency (of which one factory has not yet supplied its statistics), two in Madras Presidency and one in Burma.

The table below shows the total quantity of cane crushed and sugar made by the factories in (*i*) Bihar and Orissa, (*ii*) the United Provinces, and (*iii*) Bombay

[1] *Sci. Repts. Agri. Res. Inst. Pusa*, 1925-26 and 1926-27.

[2] Fred, E. B., and Davenport, A. Organic Compounds and Nitrification. *Soil Science*, Vol. XI, p. 389.

Gawda, N. Oxidation of ammonia and nitrates by microorganisms under different conditions. *Soil Science*, Vol. XVII, p. 57, 1924.

and Madras Presidencies and Burma. The production of sugar direct from cane in India totalled 17,16,426 maunds or 62,941 tons during the season 1926-27, as compared with 14,45,061 maunds or 52,990 tons during the previous season.

There was thus an increase of 2,71,365 maunds or 9,951 tons in the output of sugar during the campaign of 1926-27 over last year.

Provinces	Cane crushed		Sugar made		Molasses obtained	
	1926-27	1925-26	1926-27	1925-26	1926-27	1925-26
	Mds.	Mds.	Mds.	Mds.	Mds.	Mds.
Bihar and Orissa	94,51,843	90,87,988	8,19,920	7,25,735	3,94,475	3,68,995
United Provinces	89,08,582	70,06,421	7,06,952	5,52,673	4,33,756	3,28,374
Bombay, Madras and Burma .	18,47,328	18,54,633	1,89,554	1,66,653	63,816	76,693
TOTAL .	2,02,07,253	1,79,49,042	17,16,426	14,45,061	8,92,047	7,74,062

It will be noticed from the above table that in 1926-27 the supplies of cane available for crushing in Bihar and the United Provinces were considerably larger, while those in Bombay, Madras and Burma slightly smaller than in 1925-26.

The average yield of sugar in India per 100 maunds of cane shows an improvement, having risen from 8·05 maunds in 1925-26 to 8·49 maunds in 1926-27. This improvement is especially noticeable in Madras, Bombay and Bihar, while in the United Provinces it is hardly worth mentioning.

During the season 1926-27 India's production of molasses by modern factories making sugar direct from cane totalled 8,92,047 maunds as compared with 7,74,062 maunds in 1925-26, or an increase of 1,17,985 maunds over the previous season. This is due to an increased amount of cane crushed this year.

The following table shows the quantity of sugar produced direct from cane during the last seven years, from which it will be seen that there is a steady increase in the output of sugar as made direct from cane. This is a healthy sign of progress as it is far more economical to make sugar direct from cane than by refining it from *gur*.

	Sugar made direct from cane
	Mds.
1920-21	6,69,291
1921-22	7,53,638
1922-23	6,51.415
1923-24	10,44,855
1924-25	9,21,950
1925-26	14,45,061
1926-27	17,16,426

Statistics regarding the production of refined sugar by refineries in India during the season 1926-27, will be collected and published in due course.

Acknowledgments are due to the Proprietors and Managing Agents of the factories for furnishing the statistics worked up in this note. [WYNNE SAYER.]

TREATMENT OF COTTON SEED.

THE following is the summary appended to the North Carolina Agricultural Experiment Station Technical Bulletin No. 26, by Mr. S. G. Lehman, on the subject :—

1. Anthracnose[1] is one of the most destructive diseases of cotton in the United States. This disease causes losses amounting to many thousands of dollars annually in North Carolina alone. It is caused by a fungus which, under present cultural practices, is known to be spread chiefly in the form of spores and mycelium lodged upon the surface and within the cotton seed.

2. The methods commonly recommended for the control of seed-borne anthracnose of cotton are selection of seed from healthy plants, seed sterilization with chemical disinfectants, corrosives, and hot water and use of old seed for planting. Each of these methods is encumbered by certain defects which make desirable the development of a more certain and more effective method of control.

3. Other investigators have with more or less success attempted to control seed-borne diseases of other plants by the use of dry heat.

4. This study on the control of cotton anthracnose began with the use of seed of the 1919 crop and a new supply of infected seed was obtained each season. The seeds were heated in quantities of 50 or 100 in an electric oven provided with a constant temperature regulator. They were germinated individually on moist blotting paper in test tubes, and each diseased seedling was examined microscopically to determine the nature of the fungus attacking it.

5. Certain preliminary experiments dealing with germination of cotton seeds and growth of the anthracnose fungus show that temperatures of 25° and 30° C. are not only very favourable for germination of cotton seed and the subsequent growth of the seedlings but also closely approximate the optimum for growth in culture of the fungus causing cotton anthracnose and for the development of the disease on seedlings. A temperature of 35° C. permits good germination of cotton seed but inhibits the growth of the fungus which causes anthracnose and prevents the development of the disease. At 20° C. germination of cotton seed and growth of the seedlings are good, but growth of the anthracnose fungus and the development of the disease are slower than at higher temperatures.

6. The germinability of air dry cotton seed was completely destroyed in 15 minutes by dry heat at 90° and 100° C. and seriously impaired after one hour at 80° C. A temperature of 70° C. for 24 hours impaired the germination of seed containing an amount of moisture normal to ordinary storage conditions, but did not re-

[1] *Glomerella gossypii.*

duce germination of seed whose water content had been reduced to 8·3 per cent. by storage under laboratory conditions. Anthracnose was greatly reduced by heating seed at 70° C. for 24 hours but was not completely eliminated by treatment at this temperature for 48 hours.

7. A temperature of 60° C. applied to air dry cotton seed either directly or after a period of preliminary drying at a lower temperature did not kill all the anthracnose.

8. Cotton seed which had been predried at temperatures of 40° to 50° C. for 24 hours or more were subjected to a temperature of 70° C. for 72 hours without marked loss of viability, but this treatment did not free the seed from anthracnose.

9. When infected cotton seed were predried at 40° to 45° C. for 24 to 72 hours or at 50° C. for 12 to 24 hours and heated at 80° C. for 24 to 72 hours, complete elimination of anthracnose was obtained in every test except one (5 out of 6) in which the heating was continued to 72 hours, but was secured in none of the tests in which heating stopped at the end of 48 hours. Little or no reduction of germination occurred as a result of these treatments.

10. When predried cotton seed were heated at 90° C. all anthracnose was killed in 24 hours in 7 out of 8 tests, in less than 24 hours in 7 out of 13 tests, and in 48 or 72 hours in the 3 remaining tests. No significant reduction in germination resulted from the treatment at 90° C. when the seed had been predried at 50° C. or above for 24 hours.

11. When predried cotton seed were heated at 100° C., complete control of anthracnose was secured in all except one (7 out of 8) test, and in this one instance the seed were heated for only 2 hours. Heating at 100° C. greatly reduced the germinability of the seed which had been predried at 50° C. or lower for 24 hours. Much better protection was obtained by predrying the seed at 60° C. for 24 hours.

12. When predried seed were heated at 95° C., complete control of anthracnose was secured in all of 14 tests in which the seed were heated longer than 8 hours, and in 4 out of the 6 remaining tests in which the seed were heated for 8 hours or less. Predrying the seed at 50° C. for 36 hours or at 60° C. for 18 to 24 hours conditioned the seed to endure the temperature of 95° C. without reduction in percentage of germination.

13. A machine for treating cotton seed in bulk with dry heat is described and illustrated. This machine is dependable and partially automatic in operation and requires only occasional attention of the operator. The viability of the seed-borne elements of the anthracnose fungus present in infected seed may be destroyed by use of this machine. In this machine, the effective treatment for control of the disease without serious diminution of germinability consists of 20 to 24 hours of desiccation at 60-65° C. followed by 12 hours of heating at 95-100° C.

14. The moisture content of cotton seeds is a factor which strongly modifies their resistance to heat and which may be used as a criterion of their ability to withstand the temperatures that are effective in the control of anthracnose. Without exception, when the moisture content after the preliminary drying was as great

as 3·9 per cent. of the oven dry weight, the viability of the seeds was seriously impaired by heating at 95° C. for 12 hours. When the moisture content after the preliminary drying was not greater than 3·62 per cent. of the dry weight of the seeds, no serious loss of viability resulted from the treatment at 95° C.

15. When the water content after drying was not greater than 3·19 per cent. of their dry weight, the seeds heated at 95° C. for 12 hours germinated more promptly than the untreated seeds used for a check. This accelerated germination is not due to any wholesome effect of the treatment on the embryo of the seed, but is to be attributed to changes in the seed coat which facilitate access of water to the embryo. Naked embryos from treated seed germinate somewhat less promptly than treated embryos, but when seeds are germinated with coats intact, this effect is completely masked and amended by the favourable changes in the seed coat.

16. The viability of the seed-borne elements of the anthracnose fungus was prolonged by storing infected seed over such desiccating chemicals as concentrated H_2SO_4 and CaO. This result shows that the death of the anthracnose fungus when infected seeds are treated with dry heat is not due to the desiccation accompanying the treatment but to a more direct effect of the heat on the fungus protoplasm. The necessary preliminary desiccation serves only to prepare the seeds to endure the high temperature used in the final stage of the treatment.

17. The thorough desiccation which occurs when cotton seeds are stored for long periods over concentrated H_2SO_4 and dry CaO, induces a condition of more or less complete secondary dormancy in many of the seeds. This condition is slowly reversible and is characterized by a very hard and dry condition of the seed coat which prevents absorption of water. The embryos of such seed germinate promptly upon removal of the seed coat.

18. The storage of infected cotton seed in hydrogen and carbon dioxide does not free the seeds from anthracnose.

ROOT-ROTTING DISEASES OF COTTON PLANTS.

Two root-rotting diseases of adult cotton plants, previously unrecorded in the West Indies, have recently been found to affect several varieties at the Research Station of the Cotton Corporation in Trinidad.

The imperfect stages of the two fungi causing these diseases both belong to the genus *Rhizoctonia*. One of the diseases which is popularly known as Root-Rot is caused by the fungus *Rhizoctonia bataticola* (Taub.) Butler. This has been previously observed causing a wilting of adult cotton in India and Egypt. It is also known on several other host plants in different parts of the world.

Attempts have been made both in India[1] and Egypt[2] to reproduce the disease on adult cotton by inoculating plants with cultures of the fungus, but without

[1] Butler, E. J. *Fungi and Disease in Plants*, Thacker Spink and Co., Calcutta, 1918.

[2] Briton-Jones, H. R. Mycological work in Egypt during the period 1920-1922. *Min. of Agri. Egypt, Tech. and Sc. Ser. Bull.* 49 (1925).

success. This may be explained by the fact that Sawada[1] in Japan, and Finlow[2] in India have shown that there is a definite correlation between potash deficiency in the soil and the incidence of the disease as it affects jute. Investigations are now being carried out to ascertain whether the above findings are applicable to the conditions under which the disease affects cotton in Trinidad.

Both Shaw[2] and Sawada have, in view of their obtaining a pycnidial stage of the fungus, identified it as *Macrophoma Corchori* Saw. It is not proposed to go fully into the taxonomic history in this short note since Ashby has informed the writer in a letter that in view of his recent findings there is a likelihood of the fungus being given a fresh name in the near future.

The second disease is known on several host plants other than cotton in Europe and the United States. It is generally known as Violet Root-Rot and is caused by *Rhizoctonia Crocorum* Pers. (D. C.). Duggar[3] states that no well authenticated instance of the occurrence of this in South America, Australia, Asia, or Africa has come to his attention. So far as is known the fungus has not been previously recorded on the cotton plant elsewhere.

Field observations in Trinidad show that the following varieties of cotton are susceptible to the diseases :—

Rhizoctonia Crocorum (Pers.) D. C.	*Rhizoctonia bataticola* (Taub.) Butler.
Nanking.	Nanking.
Dharwar-American.	Dharwar-American.
Broach Type (*G. herbaccum*) 1A9.	Sea Island A. N.
Sea Island A. N.	Cawnpore (*G. arboreum*).
	Million Dollar.
	Buri from Nagpur.
	Upland Cassava.

The following figures show the extent of the diseases in a plot one half of which had been given a dressing of pen manure before sowing :—

Manured		Unmanured	
Number of healthy plants . . .	87	Number of healthy plants . . .	91
Number of diseased plants . . .	nil	Number of plants with *R. Crocorum* .	20
		Number of plants with *R. bataticola* .	1
		Number of plants with *R. Crocorum* and *R. bataticola*	5

[1] Sawada, K. *Agric. Exp. St. Govt. of Formosa Bull.* 107, Nov. 1916 (Japanese). *Mycologia*, Vol. XI, p. 82, 1919.

[2] Shaw, F. J. F. Studies in diseases of the Jute plant. (2) *Macrophoma Corchori* Saw. *Mem. D. of Agri. India, Bot. Ser.*, Vol. XIII, No. 6, Sept. 1924.

[3] Duggar, B. M. *Rhizoctonia Crocorum* (Pers.) D. C. and R. *Solani* Kuhn (*Corticium vagum* B. and C.) with notes on other species. *Ann. Miss. Bot.* Edn. 2, 403-458 ; Sept. 1915.

In another plot which had not been given any manuring 3 per cent. were affected with *R. bataticola* and 1 per cent. with *R. Crocorum*. [*Trop. Agri.*, IV, No. 5.]

IMPERIAL INSTITUTE.

WE have received the following from the Director, Imperial Institute, London :—

You are no doubt aware that considerable changes have been made in the organization of the Imperial Institute as a result of the recommendations of Mr. Ormsby Gore's Committee of Enquiry, which were approved by the Imperial Economic Conference in 1923.

Under the provisions of the Imperial Institute Act of 1925, the Institute has been placed under the control of the Department of Overseas Trade, and the Parliamentary Secretary of that department is the responsible Minister and Chairman of the Board of Governors. The work of the Institute, as regards Intelligence and Investigations, is now organized under two principal departments, *viz.*, a Plant and Animal Products Department and a Mineral Resources Department (in which has been incorporated the late Imperial Mineral Resources Bureau), and a representative Advisory Council has been appointed for each of these groups.

The Advisory Council on Plant and Animal Products, of which Sir David Prain, C.M.G., C.I.E., F.R.S., is the Chairman, was formed in March 1926, and its principal functions are to advise on all matters relating to the utilization of these groups of Empire raw materials and to initiate schemes of work which might be undertaken by the Institute. In order to facilitate this work the Council has appointed a number of Advisory Technical Committees to deal with special subjects on the lines of the Institute Committees on Silk and Timbers which were established in 1916. The Committees at present constituted are as follows :—

Subject	Chairman
Silk	Sir Frank Warner, K.B.E.
Timbers	Mr. H. D. Searles-Wood, F.R.I.B.A.
Vegetable Fibres	Mr. Alfred Wigglesworth.
Animal Fibres	The Hon. Sir George Fairbairn.
Oils and Oil-seeds	Dr. A. W. Hill, C.M.G., F.R.S.
Essential Oils and Resins	Mr. A. Chaston Chapman, F.R.S.
Tanning Materials	Sir David Prain, C.M.G., C.I.E., F.R.S.

Committees on other products will be formed as and when required.

Each of these Committees has a member of the Advisory Council as Chairman and includes scientific and technical authorities as well as representatives of the trades and industries concerned in the particular group of products.

Since 1913, investigations of plantation rubber have been carried out at the Institute on behalf of the Ceylon Rubber Research Scheme. The necessary facilities, including adequate laboratory accommodation, have been provided by the

Institute, and the work is conducted by a specially appointed staff under the direction of the London Committee of the Scheme, of which Mr. P. J. Burges, M.A., is the Chairman. The investigations deal with problems relating to those properties of plantation rubber and its industrial utilization which can best be studied in this country in close association with manufacturers, representatives of whom are members of the Committee.

The Advisory Council on Plant and Animal Products and its associated Technical Committees, in conjunction with the Intelligence and Laboratory Sections of the Department, constitute an organization designed to obtain authoritative opinions on all questions relating to the production, utilization and marketing of Empire raw materials of plant and animal origin, and it is hoped that your department will continue to make the fullest use of the facilities offered. The Council and the Committees are anxious to assist in developing the resources of the Empire and will welcome enquiries on any subjects, and samples of any products, which may be under consideration by your department.

The work of the Institute would, I feel, be greatly benefited if you and the members of your staff were able to visit the Institute when in this country in order to discuss the various problems in which your department is interested. Arrangements could then be made, if you or your officers could spare the time, for their attendance at meetings of the Advisory Council or appropriate Committees. The personal contact thus established could not fail to be of the greatest value in promoting the objects we all have in view.

As an illustration of the valuable services which the Technical Committees can render to the Colonies, I would refer to the article by Mr. Norton Breton on "The Cyprus Silk Industry," which appeared in the "Bulletin of the Imperial Institute," No. 3 of 1926. The establishment of the silk filature in Cyprus is the direct outcome of several years' careful work by the Institute's Advisory Committee on Silk.

The Institute is now in close touch with Government departments and other institutions engaged in research, and materials requiring scientific investigation, or specialized enquiries, are at once passed for action to the appropriate body. The Institute thus acts as the central clearing house for enquiries from all parts of the Empire in accordance with the recommendations of Mr. Ormsby-Gore's Committee.

It is the desire of all connected with the Institute to assist to the utmost in developing the natural resources of the Empire, and for this purpose it is essential to secure the co-operation of the technical departments overseas—a co-operation on which I feel sure we can count.

Personal Notes, Appointments and Transfers, Meetings and Conferences, etc.

MR. G. S. BAJPAI, C.I.E., C.B.E., I.C.S., has been appointed to officiate as Secretary to the Government of India in the Department of Education, Health and Lands, from 16th December, 1927.

MR. A. B. REID, I.C.S., has been appointed temporarily Joint Secretary to the Government of India in the Department of Education, Health and Lands, from 16th December, 1927.

MR. A. M. MUSTAFA, B.A., Agronomist, Agricultural Research Institute, Pusa, has been appointed to officiate as Agricultural Officer, North-West Frontier Province, *vice* Mr. W. Robertson Brown granted leave.

MR. R. D. ANSTEAD, M.A., C.I.E., Director of Agriculture, Madras, has been granted leave from 4th January to 19th February, 1928, with permission to prefix the Christmas holidays.

MR. G. R. HILSON, B.Sc., has been appointed to officiate as Director of Agriculture, Madras, *vice* Mr. Anstead on leave.

MR. R. C. BROADFOOT, N.D.A., has been appointed to officiate as Cotton Specialist, Madras, *vice* Mr. Hilson on other duty.

MR. C. NARAYANA AYYAR has been placed in charge of the office of the Deputy Director of Agriculture, VI Circle, Madras, *vice* Mr. Broadfoot on other duty.

MR. D. A. D. AITCHISON, M.R.C.V.S., Veterinary Adviser to the Government of Madras, has been granted leave from 21st November, 1927, to 19th May, 1928, preparatory to retirement.

MR. F. WARE, F.R.C.V.S., Principal, Madras Veterinary College, has been appointed to act as Veterinary Adviser to the Government of Madras, *vice* Mr. Aitchison granted leave.

MR. S. D. JOSHI, B.Sc., Research Assistant to the Plant Pathologist, United Provinces, has been appointed a Deputy Director of Agriculture in a temporary capacity for six months, and is posted to the Hills Circle with headquarters at Jeolikote.

MR. W. GREGSON, N.D.A., Deputy Director of Agriculture, Northern Circle, Burma, has been granted leave on average pay for 8 months from 7th November, 1927.

On return from leave, MR. D. RHIND, B.Sc., is posted to Mandalay as Economic Botanist, Burma.

REVIEWS

Economics of Agricultural Progress—By PROFESSOR B. G. SAPRE, Willingdon College, Sangli.

The first three chapters of this volume are devoted to an examination of the conditions underlying agricultural prosperity and to a discussion on the interdependence of industrial and agricultural progress in India. Although dealing with much matter that is controversial, Prof. Sapre has presented a reasoned and readable defence of the economic views which he upholds. By way of criticism, it may be suggested that the evident suspicion with which he views every effort made by Government to inaugurate and develop material schemes of improvement in India as being " primarily viewed from the point of its bearing upon British trade and only incidentally, of its bearing upon the happiness and prosperity of the people ", is hardly consistent with the author's repeated demand for increased Government intervention and help which is made vocal in nearly every chapter of his book. Furthermore, it is difficult for anyone with a knowledge of the work done by the Indian Central Cotton Committee to believe that the cotton mill industry " has little value from the point of view of the development of the country, " or that " the industry does not convert raw produce into a manufactured article but only facilitates and cheapens the export of the raw produce itself." However, there is much in these chapters which will stimulate the student of agricultural economy in India and which is worthy of careful consideration by all interested in Indian agriculture.

In the remaining portion of his book, Prof. Sapre examines the problems of irrigation, fragmentation of holdings and agricultural debt with special reference to the Bombay Deccan. All these chapters are interesting and, although we do not agree with many of the author's conclusions, we cannot fail to appreciate the value of his arguments and their able presentation to the reader. In his obvious desire to emphasize the " sins of omission and commission " of Government, the author has a tendency to overlook certain important facts bearing on the problems he is discussing. For instance, in his anxiety to shoulder Government with the main responsibility for the decay of well and *patasthal* irrigation in the Deccan, no mention has been made either of the rapid increase of dry cotton cultivation as the chief money crop or of the inevitable ruination of recuperative sources due to over-use of such forms of irrigation in the past. In our opinion, either of these factors alone has been of much greater importance in bringing about the present state of affairs than the small charges levied by Government on such forms of irrigation. Professor Sapre's chapter on " Consolidation and Liquidation " is well worthy of

perusal, and his review of the methods which have been tried in dealing with these problems is most interesting and valuable.

In his last chapter, Prof. Sapre has endeavoured to give a few suggestions and recommendations for future progress. We are candidly not impressed by this portion of the book which does little but summarize a few of the main points which will be placed before the Royal Commission on Agriculture in India by every witness with any knowledge of Indian agriculture. The author lays great stress upon the provision of pure seed to the cultivator, but, curiously enough, he has little if anything to say about the extension of improved methods of cultivation, without which the introduction of pure seeds, manures, better implements, etc., can only bring a very depreciated return to the cultivator. Similarly, in our opinion, the knowledge of how to *grow* the crop is of much greater value than the knowledge of how to save it, important as the work of mycologists and entomologists in India must always be.

The exhortation with which this interesting book is prefaced is a very potent appeal to all lovers of India and her rural population, and forms an inspiring prologue to a volume which, while calling forth criticism, is nevertheless a useful contribution to India's agricultural and economic literature. [W. J. J.]

Popular Zoology (in Marathi).—By VISHNU NARAYAN GOKHALE, B.AG., B.SC., AND VASUDEV GANESH DESPANDE, B.AG. Price, R 1.

We have previously in these pages drawn attention to recent useful publications in the scientific vernacular literature of the Bombay Presidency. The volume under review is the most recent of these and is exceedingly valuable as a text-book for nature study in the schools. It is of a handy size, moderate in price and has admirably drawn original illustrations. In fact we do not remember to have seen a recent popular science book so well illustrated. The drawings are the work of an Indian artist. The authors are two of the younger staff of the Poona College of Agriculture, and we trust that they will continue to put forth books of similar quality and that the response by the public as shown in the sales of these books will be satisfactory. [W. B.]

CORRESPONDENCE

VARIABILITY IN THE GINNING PERCENTAGES IN CROSSES OF INDIAN COTTONS.

To The Editor,

The Agricultural Journal of India.

Sir,—I should be glad if you would allow me to offer certain remarks regarding the very interesting article contributed by Mr. Rama Prasada on the above subject to the January (1927) Number of the Journal.

While appreciating very highly the material presented by the author, in one or two matters I do not think his data bear the interpretation which he has placed upon them. His statement that there is a gradual rise in the ginning percentage as the result of selection is not, I think, justified by his facts. For example, a cross between *Gossypium neglectum* and *Gossypium arboreum* yielded one plant in 1911 which ginned 31 per cent. and was desirable in all respects except that of ginning percentage. Twenty individuals raised from this plant gave, in the following year, an average of 29·5 per cent. ginning. The variation which is shown in Table I, line 2, indicates, in fact, that this plant bred true to low ginning character.

If we now examine the figures in the table quoted on which the statement as to the gradual improvement in ginning percentage is made, it will be seen that the *average* ginning percentage does show an increase which might be said to be gradual. The character of the variations in 1913, 1914, and 1915 shows quite differently from that of 1912, and the variability is *bimodal* in each case. In the year 1914 there is distinctly one mode at 32 per cent. ginning and another at 37 per cent. ginning, which shows clearly that we have in this case an intermingling of high and low ginning strains. This intermingling in the progeny of a low ginning strain can only be explained by natural crossing with a high ginning cotton. The improvement in ginning percentage from 29 to 37 is much more likely to be due, therefore, to crossing with a high ginning cotton than to selection alone as suggested by Mr. Rama Prasad.

Yours faithfully,

G. L. KOTTUR,

Dharwar. *Cotton Breeder, S.M.C.*

NEW BOOKS

On Agriculture and Allied Subjects

1. Soil and Civilization : A Modern Concept of the Soil and the Historical Development of Agriculture, by Milton Whitney. (Library of Modern Sciences.) Pp. x+278+5 plates. (London : Chapman and Hall.) Price, 15*s*.
2. Sheep Production, by L. J. Horlacher. Pp. x+418. (London : McGraw Hill Publishing Co.) Price, 20*s*. net.
3. Animal Nutrition, by T. B. Wood, Second edition. Pp. VIII+226. (London : University Tutorial Press.) Price, 3*s*. 6*d*.

The following publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Memoirs

1. *Pennisetum typhoideum* : Studies on the Bajri Crop, I—The Morphology of *Pennisetum typhoideum*, by S. V. Godbole, M.Sc., B.Ag. (Botanical Series, Vol. XIV, No. 8.) Price As. 12 or 1*s*. 3*d*.
2. Studies in Khandesh Cotton, Part I, by S. H. Prayag, M.Ag. (Botanical Series, Vol. XV, No. 1.) Price, Re. 1-4 or 2*s*. 3*d*.
3. The Chemotherapy of Surra (*Trypanosoma evansi* Infections) of Horses and Cattle in India, by J. T. Edwards, D.Sc., M.R.C.V.S. (Veterinary Series, Vol. IV, No. 1.) Price, Rs. 4-2 or 7*s*.
4. Studies in Bovine Lymphangitis, by V. Krishnamurti Ayyar. (Veterinary Series, Vol. IV, No. 2.) Price, Rs. 1 3 or 2*s*.

Bulletin

5. Seasonal Variation in the Germ Content of Milk at Pusa, by J. H. Walton, M.A., M.Sc. (Pusa Bulletin No. 170.) Price, As. 6 or 8*d*.

Reports

6. Scientific Reports of the Agricultural Research Institute, Pusa (including the Reports of the Imperial Dairy Expert, Physiological Chemist, Government Sugarcane Expert, and Secretary, Sugar Bureau), for the year 1926-27. Price, Rs. 1-14 or 3*s*. 3*d*.

ORIGINAL ARTICLES

THE IMPERIAL AGRICULTURAL RESEARCH CONFERENCE.

BY

F. J. F. SHAW, D.Sc. (LOND.), A.R.C.S., F.L.S.,

Offg. Imperial Economic Botanist, Pusa.

THE Imperial Agricultural Research Conference was held in London during October 1927 and was attended by delegates from Great Britain and the Overseas territories of the British Empire. The Conference met in the Grand Committee Room of the Houses of Parliament, amid the historic associations of the Palace of Westminster, under the able chairmanship of Lord Bledisloe. The object of the Conference was the consideration of the means whereby agricultural research all over the Empire could be developed, and more particularly whether the creation of central organizations for the dissemination of information or for the conduct of research would result in an improved liaison between research workers all over the Empire and a consequent greater unity of effort and more rapid advancement in research. The Conference, it will become apparent, has done its work well and if its many recommendations and proposals are effectively endorsed by the various Empire Governments we may look for a great record of achievement in agricultural research in the British Empire in the immediate future.

The first subject considered by the Conference was the proposed chain of research stations in the tropical and sub-tropical colonies of the Empire. This subject was discussed at the Imperial Conference in 1926 and this Conference passed a resolution expressing its cordial approval of " The project of fostering a chain of research stations situated in the tropical and sub-tropical parts of the Empire, and commending this project to the sympathetic consideration of Governments, Institutions and private benefactors throughout the Empire." The Colonial Office Conference of 1927 accepted " the necessity for a chain of group research stations throughout the Empire" and pointed out that for this purpose the Colonies fell into the following groups :—West Africa, East Africa, West Indies, Far East and Middle East. The Governments of the Empire have thus unanimously agreed that measures should be taken to establish an Empire chain of research stations on tropical and sub-tropical agriculture, and the Imperial Agricultural Research Conference was also in cordial general agreement with the proposed scheme and was unanimous in laying down certain broad general principles concerning the establishment and nature of the proposed stations. The Conference considered that the establishment of central tropical and sub-tropical research stations should be governed primarily by the ascertained needs of Empire research in particular fields of agriculture, rather than by considerations of geographical distribution. Stations for

dealing with problems suitable for such treatment should be located in territories affording specially advantageous conditions for the study of each such problem. It was also the unanimous opinion of the Conference that the stations should, in the main, confine themselves to "long range" and "wide range" research, *i.e.*, that they should concentrate on (*a*) problems requiring more prolonged research work than can normally be expected from the technical staff of any single administrative department; (*b*) problems arising in more than one territory of the Empire towards the solution of which the comparative method may be expected to make an effective contribution. In accordance with these principles it is probable that a central research station will have some special branch of research as its main function and the Conference urged the establishment at an early date of research stations in diseases of animals and in irrigation. The Conference also emphasized the importance of preventing the establishment of a central research station from being allowed to impair or replace the scientific work properly undertaken by the Agricultural Department of any Government in its proximity. It conceived the work of such stations as a re-inforcement of the local Agricultural Departments and in no sense as a substitute for their work. The work undertaken by a central research station would from time to time enable it to afford valuable advice to Agricultural Departments in its neighbourhood, but the Conference did not consider that it should be regarded as a function of a central station as such to provide such advice, except as the direct result of its research activities. This conclusion, however, was not to be taken as debarring a central station, in special conditions such as those of the West Indies, from being treated as a convenient base of operations for a travelling advisory staff. The Conference was most emphatic that a research station as such should not be expected to undertake any teaching work except insofar as the advanced instruction of a limited number of post-graduate students could be undertaken with advantage to the research work in progress.

At the present moment when the relationship of central research bodies to local Agricultural Departments is a matter of such interest in India it is worth noting how closely the objects and functions which the Conference considered appropriate for the proposed central research stations agree with those which have been carried out in the past by the central research stations maintained by the Government of India. The proposed scheme for a chain of research stations is one of great importance for India since within the boundaries of the Indian Empire there are realized practically all the conditions of soil and climate which prevail in the tropical parts of the Colonial Empire. The work carried out in the proposed stations in the colonies would have a wide application and would inevitably be of use to India just as the results of the research in agriculture in India during the past 30 years are proving of utility to agriculture in many tropical and sub-tropical agricultural regions outside India. It is in the field of long range research work in tropical conditions that the present organization of research work is largely deficient. In most tropical countries agricultural departments and research institutions wherever organized

are maintained almost solely by the State or by particular industries. Examples of the last are furnished by the Scientific Department of the Indian Tea Association and the Rubber Research Institute in Malaya. Problems of immediate and sometimes temporary importance are forced to the notice of State Agricultural Departments and institutes maintained by industrial or planting organizations and it is difficult in these circumstances for the research worker to devote continuous attention to fundamental problems, yet much of the direct research work which is done by such institutes derives its inspiration and direction from ong range research work previously conducted. In India we may congratulate ourselves that the provision for long range research on fundamental problems has in the past been greater than that in any other of the tropical and sub-tropical parts of the Empire. At the present moment the only research stations in the Empire of an inter-colonial character are those at Trinidad and at Amani in Tanganyika Territory. The realization of a complete chain of Empire research stations must inevitably be slow owing to the shortage of qualified research workers available for the staffing of the stations of this kind.

So large a part of the tropical and sub-tropical areas of the British Empire lies within the Colonial Empire, that a majority of the stations proposed must be looked for in colonial territories. Stations will, however, come into existence in the Dominions and at the present moment the Commonwealth Government, in consultation with the Empire Marketing Board, are planning a research station in Northern Queensland of which the capital cost and the maintenance expenditure would be shared equally by the Empire Marketing Board and the Australian Government. The Conference recognized that any extension of the chain of Empire research stations to include the Dominions and India must be a matter for further consideration by the Governments concerned and that the control of any such station must be vested in the overseas government of the territory in which it is established.

The Conference devoted several sessions to the consideration of how far it is practicable to make arrangements on an Imperial basis for the recruitment, training and interchange of research workers in agriculture. The Conference concluded that recruitment and post-graduate training were not appropriate subjects for organization on an Imperial basis and therefore dealt with these subjects primarily in connection with the Colonial Empire. The Conference urged the establishment of a unified Colonial Agricultural Service with a common system of emoluments, promotion and super-annuation. The method of recruitment and the academic standard which would be required of candidates for a Colonial Agricultural Service were considered by the Conference which in general approved of principles similar to those on which the Indian Agricultural Service has been recruited. That at the present time a project for the unity of the agricultural service in the widely separated and diverse territories of the Colonial Empire should be unanimously approved by the most representative gathering of Empire agricultural research workers which

has ever met is not without its lesson for India, which, in comparison with the Colonial Empire, forms a relatively homogeneous area.

Perhaps the most important and certainly the most difficult of all the subjects before the Conference was that relating to the interchange of scientific information and the possible increase in the number of Imperial Bureaux. The Research Special Sub-Committee of the Imperial Conference of 1926 referred to the great value of the work of the Imperial Bureaux of Entomology and Mycology and suggested "further bureaux of a similar kind might well be established in other sciences as the need for them is realized and the constituent parts of the Empire agree to their establishment". It was the task of the Imperial Agricultural Research Conference to consider how far the need for new bureaux was felt throughout the Empire and how the creation of such bureaux would facilitate the interchange of scientific information among Empire research workers.

From discussions in the plenary sessions of the Conference and from the reports of the various committees of the Conference, which were established to deal with technical subjects, it became apparent that, while the full bureau organization might be desirable for certain subjects in the case of many branches of agricultural science, a smaller and less expensive type of organization would meet the requirements of workers. The Conference, therefore, recommended that new and complete bureaux should be established for the subjects of Soil Science, Animal Nutrition and Animal Health, and that smaller "clearing stations of information" or "correspondence centres" should be established for Animal Genetics, Agricultural Parasitology, Plant Genetics and Fruit Production. In defining the function of a bureau or correspondence centre, the Conference stated that the functions of a clearing station should be to collect, collate and disseminate information of a scientific and technical character; to reply to enquiries on scientific and technical problems from agricultural departments and scientific workers in any part of the Empire; and particularly to facilitate intercourse among groups of workers on closely allied problems. As a clearing station, whether a full bureau or a correspondence centre, would have as one of its main functions the collection and dissemination of information, it was considered that the most suitable location for a clearing station would be where a body of information, a staff of workers and the necessary scientific atmosphere already existed, *i.e.*, in proximity to or in connection with an existing research institution. The simplest and the most economical method of establishing a station is, therefore, so to add to the staff of an existing research institution as to enable it to undertake the additional duties imposed upon it. On general principles, the Conference recommended the establishment of clearing stations in small numbers and on a modest scale as it was believed that only through experience could the best results be obtained.

In the case of the new bureaux the Conference recommended that the Bureaux of Soil Science should be attached to Rothamsted and that the Bureau of Animal Nutrition should be attached to the Rowett Research Institute, Aberdeen. With

regard to Animal Health, the importance of this subject appeared to the Conference to be so great that the immediate establishment in London of a bureaux to deal with this subject was recommended. The new bureaux would include and absorb the section dealing with tropical animal diseases at present contained in the Bureaux of Hygiene and Tropical Diseases, and would have the advantage of the facilities available at the Natural History Section of the British Museum, which have been so fruitful in the case of the Bureaux of Entomology and Mycology.

There was undoubtedly in the Conference a feeling that of all the new bureaux and correspondence centres the most important and urgently required was that of Animal Health. The technical committee of the Conference which considered this subject and which had the advantage of the presence of Sir Arnold Theiler in the chair, reported that "If there is one need which our meetings and deliberations have emphasized more than anything else, it is the need for a central organization of some sort that may act as a clearing house for information relating to animal health, and serve as a connecting link between our various workers throughout the Empire. The collection, collation and dissemination of information alone is not, however, sufficient for our needs. It is also necessary that our workers, and those of us in particular who work in isolated districts, should have a central organization that may be approached when there is need of information or advice on particular problems.

"We propose to give briefly a few concrete examples of the disadvantages under which our workers have suffered in the past through the lack of a common centre of information.

(1) In the sixties the pastoral industry of Australia and New Zealand was faced with ruin through the ravages of sheep-scab. Steps taken by the authorities to deal with this disease were so successful that in the course of a few years "scab" was completely eradicated; and the flocks of the Commonwealth and of New Zealand have remained free ever since. There is no record published of the exact procedure which brought about this excellent result. 'Scab' is still prevalent in many other parts of the Empire, and the experience of Australia and New Zealand might have been invaluable in combating the disease in other countries.

(2) In the eighties, pleuro-pneumonia was imported into South Africa in Angora goats, and was successfully treated and eradicated by Hutcheon by a method of inoculation. The details of the method adopted were not made public, and are lost to science.

(3) Active campaigns for the elimination of tuberculosis are being prosecuted at present in several different countries. This disease is of direct importance to many parts of the Empire, and it is most desirable that the fullest possible information both as to methods adopted and the results achieved in different countries, should be made avail-

able for the benefit of all our workers. Further, the results of the researches on immunity and vaccination now being carried on in various parts of the world, would be particularly valuable in combating this scourge. They are being tested in different parts of the Empire, and with fuller information it should be possible to secure such co-operation as would ensure the most thorough testing of the methods without unnecessary overlapping. Similarly, methods for the diagnosis of tuberculosis vary considerably and a rapid interchange of information in this connection is necessary.

(4) Contagious abortion is causing very serious economic loss at present practically throughout the Empire, and it is highly desirable that the methods of control and diagnosis now in operation and the progress made in the various parts of the Empire should be widely known.

(5) To take a recent example, we might instance the dearth of knowledge in this country regarding foot-and-mouth disease when a Committee was appointed in 1924 to investigate this disease. Despite the fact that Continental workers had been probing the problem for many years, there was no bibliography of their recorded work and much valuable time had to be spent in searching for reports of previous workers."

(6) This report which also elaborates the type of organization and the financial provision required was unanimously adopted by the Conference.

The recommendations of the Conference on the subjects of bureaux and interchange of information constitute what is perhaps the most direct and practical contribution which the Conference has made to the furtherence of agricultural research within the Empire. These recommendations express the feeling in the Conference, which grew stronger as the Conference drew to its close, of the paramount importance of co-operation in agricultural research and of the close dependence of the progress of research in one part of the Empire on the results achieved and investigations in progress in another part of the Empire. It is with the object of ensuring easy intercourse between groups of workers in allied problems and the collection and dissemination of information upon important technical subjects that the Conference has proposed three new bureaux and four correspondence centres.

The Conference on many occasions during its meetings gave expression to its sense of the importance of periodical conferences of research workers and a suggestion was put forward, and approved by the Conference, of a regional conference of research workers of the dependencies and territories of the Empire in the Far East. In such a conference India's place as the largest and most densely populated territory of the Empire in the East would be of the first importance. An invitation from the Commonwealth Government that the next meeting of the

Conference should be held in Australia was enthusiastically accepted by the Conference.

It is impossible within the limits of an article in this Journal to do justice to all the activities of this Conference. In addition to the important administrative subjects which have been dealt with in this article, many technical subjects were considered by specialist committees, consisting of experts in these particular subjects. The reports of these committees mostly dealt with the formation of bureaux and correspondence centres and were adopted by the Conference proving of great assistance to the Conference in the framing of the general policy on bureaux and the interchange of information. Two subjects, Mycology and Entomology, were fortunate in already possessing established and highly successful bureaux and the committees on the subjects were therefore able to devote their attention to more technical matters. The Mycological Committee gave an entire session to the problem of virus diseases which are the cause of heavy loss in many crops all over the world. The Committee unanimously recommended that special funds and staff should be provided for the extended study of the fundamental nature of virus diseases in plants. The heavy loss which India suffers in the sugarcane and other crops makes this country a very suitable area for investigations of this nature.

The Conference toured to Cambridge, Edinburgh, Aberdeen, Belfast, Rothamsted, the Imperial College of Science and Technology and many other centres, and the delegates were thus able to inspect the principal centres of agricultural research in Great Britain. Perhaps the most interesting and certainly the most unique institution visited was the great works for the manufacture of synthetic ammonium sulphate and other fertilizers of Messrs. Brunner, Mond and Co., at Billingham. It is due to these works that Great Britain is the second largest producer of combined nitrogen in the world, and should shortly become independent of any imported supply. In addition to the scientific staff necessary for the successful working of its manufacturing processes the company maintains a research laboratory and is establishing an Agricultural Research Station to which is attached a farm of 400 acres. Its object is to explore and if possible solve the many fresh problems to which the new fertilizers are giving rise.

The Imperial Agricultural Research Conference was unique in being the first gathering, representative of all parts of the Empire, of research workers in the oldest, greatest and most fundamental industry of Great Britain and her Overseas Empire. The mere fact that such a Conference has been held is a recognition of the importance which all governments within the Empire are attaching to research and above all to agricultural research. At the present moment, when the organization of agricultural research in India is one of the great problems before the country, the unanimous recommendations of this Empire Conference for a unified system of recruitment for a Colonial Agricultural Service, for a closer liaison between research-workers in different parts of the Empire and for a central research organization for the study of fundamental problems, point out the path of progress.

ARTIFICIAL FARMYARD MANURE.

BY

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AND

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FARMYARD manu e, the excrement of domesticated animals, plus litter and other organic refuse, is the common manure wherever the farmer is civilized enough to use manure at all. This of course applies to India, where farmyard manure is certainly the principal and, in most tracts, the only fertilizer used by the cultivator. Unfortunately with the increase of population and the lessening of jungle areas, the supply of fuel has correspondingly contracted, and dried cattle dung is now in common use as a substitute fuel all over India. On burning the cowdung, its ash constituents remain and are not necessarily lost, though the latter must be the case in all urban areas. In any case, the whole of the nitrogen, the most valuable constituent, and the organic matter, which has so profound an effect on the physical condition of the soil, are both volatilized and dissipated into the air.

Other manures, such as cakes, bone and mineral manures, may be substituted for farmyard manure, but none are so uniformly satisfactory. Moreover, even if they were not more expensive, the fact that they cost money is sufficient to severely restrict their use by the ordinary ryot, especially in North-Eastern India, where holdings are so small and where floating capital does not exist.

It has thus become exceedingly important to discover some cheap and effective way of making up for the great loss of valuable cattle dung which the present position in regard to fuel renders necessary. The following is a short account of work which has been done on the subject at the Government Central Research Station at Dacca and the results which have been obtained.

Investigations into the process of retting of jute, and into the decomposition of damp baled jute, were commenced by one of us before 1910. In 1916 Hutchinson[1] showed that controlled decomposition of sann-hemp green manure increases its efficiency. Later the writers' work on jute was extended to straw, sisal waste and

[1] Hutchinson, C.M. *Pusa Agri. Res. Inst. Bull.* 63.

Artificial Farmyard Manure in Manufacture at Dacca.

green manure. It should be explained that sisal waste is typical of the mass of parenchymatous tissue obtained in the decortication of sisal and other leaf fibres. In the initial stage of the retting of jute, also in the bacterial decomposition of sisal waste, a copious acetic acid fermentation takes place. Later the acidity diminishes and apparently vegetable proteids and other complex organic nitrogen compounds are decomposed with formation of ammonia, which is found later in the residue as ammonium acetate. In the decomposition of *Indigofera* and probably also in the case of other Leguminosæ, a somewhat similar reaction takes place, but there is less initial acid formation and the residue in the final stage is distinctly ammoniacal. Simultaneous experiments showed that in bacterial fermentation of extracted fibres and previously dried cellulosic organic matter, such as straw, or sugarcane begasse, nitrogen gas, with varying proportions of marsh gas (CH_4), hydrogen and carbonic acid (CO_2), is liberated. In other words, the process of decomposition in these cases is that known as denitrification. This is entirely in accord with Hutchinson's observation at Pusa that, with green manure, it is the leaf rather than the stem or the nitrogen accumulated in the root of a green manure which ultimately immediately affects the fertility of the soil to which the green manure is applied. On the other hand, although the decomposition of fibrous matter involves loss of nitrogen, there is evidence that this process is responsible for the production of humus in the soil. Further work by the writers shewed that moisture conditions in the soil at the time of ploughing in a green manure profoundly influence its beneficial effect. The results indicate that in a water-logged soil, such as would be encountered in the monsoon in a wet climate like that of North-Eastern India, almost complete decomposition of the green manure takes place, within a very short period, with the result that little or no fertilizing effect is produced. On the other hand, if the green manure is turned in, in conditions of moderate soil moisture, either before or just after the monsoon period, the effect of the green manure is considerably enhanced. This is by the way, and it is necessary to return to the subject of the present communication.

In 1921, Hutchinson and Richards, in collaboration with Lord Elveden at Rothamsted, England, published results of experiments, conducted with a view to assisting the re-inforcement of the supply of farmyard manure in England. The conclusions of Hutchinson and Richards were much the same as those detailed above; but, in addition, they placed on the market a substance called "Adco," containing nitrogen and phosphates, and supplied by Messrs. Shaw Wallace & Co. of Calcutta, which facilitates the decomposition of organic refuse into valuable manurial material.

In view of the valuable practical lead given by Rothamsted, and in extension of their own former work, the writers proceeded to attempt the manufacture of artificial farmyard manure on a considerable scale. Cattle urine and washings from the cattle sheds collected in a sump, *plus* a small amount of bonemeal, were used and immediate success was obtained. Weeds, jungle grass, sugarcane trash and begasse, refuse straw, etc., all proved capable of breaking down into excellent

manurial material approximating more or less closely in appearance and in composition to that of cowdung. In the present year it is estimated that about 4,000 maunds (say 150 tons) of first class manure have been made at the Central Research Station at Dacca, from material of which, formerly, the greater proportion was wasted. It may be added that, for the first time in its history, the Dacca farm has had an ample supply of farmyard manure; also that this happy condition is due largely to the production of artificial farmyard manure on a serious scale, as a normal item in the farm routine.

In the monsoon, in North-Eastern India, the soil water level reaches the surface and the artificial manure is made in heaps; but in the dry weather, in North-East India and elsewhere, pits should be used, as otherwise the rapid loss of moisture creates difficulty and necessitates extra labour in re-making the heap.

Cattle urine, diluted about 10 times, and containing between 0·05 per cent. and 0·1 per cent. nitrogen was originally used in preparing artificial farmyard manure.

Early experiments at Dacca were as follows:—In the dry weather season, 25 maunds (2,000 lb.) of sugarcane trash (dried leaves) was placed in each of two pits and was moistened, in the one case with urine diluted as above, and in the other with a solution of ammonium acetate containing 0·05 per cent. of nitrogen. In the latter case, a little sodium phosphate was also added. Roughly 100 c. c. (say ¼ lb.) of the 0·05 per cent. solutions of urine or ammonium acetate, added to sufficient water to thoroughly damp the material, were used with every 25 lb. of trash. After about 4 months the compost was tested and found to be well rotted, having an appearance something like farmyard manure. The outturn of approximately 10 mds. of dry trash gave 30 maunds of moist compost. The chemical analyses showed:—

	1. Compost with urine	2. Compost with ammonium acetate:—
Moist	68·34	67·82
K_2O	0·462 (dry basis)	0·2633 (dry basis)
P_2O_5	0·3806 „	0·2060 „
N.	0·319 (moist basis)	0·2109 (moist basis)
	1·007 (dry basis)	0·655 (dry „)

In actual field tests carried out in triplicate plots, the compost made with liquid manure gave a slightly higher yield than ordinary cowdung, but the ammonium acetate compost gave less.

In building the heap for fermentation, the material was treated every foot with liquid manure and a sprinkling of bone dust till the heap reached 7—9 feet high. A barrel (capacity about 10 maunds) of diluted liquid was sufficient for one heap, but this of course varied with the season of the year, as, during fermentation, it was essential to keep the compost moist. A fairly high temperature of over 100°F. was set up inside the heap and this lasted a considerable time. About 3 or 4 months was the usual time required to bring the compost to a state when it could be used as

manure. But here again the time depended not only on the season of the year but also on the materials used.

The success obtained on the Dacca farm was repeated on other farms, and, for some considerable time now, all Government farms and sericultural nurseries in Bengal have been making their own artificial farmyard manure.

As already stated, this has meant a very considerable increase in the supply of available manure.

The following analytical results may be of interest :—

1. *Material—Weeds and litter.*

Nitrogen 0·567 per cent. (moist sample).
1·29 per cent. (oven-dry sample).
Moisture 56·05 per cent.
Loss on Ignition 9·19 per cent.
P_2O_5 0·28 per cent. (moist sample).
0·64 per cent (dry sample).
Ash 34·75 per cent. (moist sample).
Insol. Residue 30·51 per cent. (moist sample)
CaO 0·30 per cent. (moist sample).
0·68 per cent. (dry sample).
MgO 0·08 per cent. (moist sample).
K_2O 0·36 per cent. (moist sample).
0·83 per cent. (dry sample).

2. *Water Hyacinth from Messrs. Shaw Wallace & Co., Calcutta.*

Moisture 84·78 per cent.
Sand 3·76 „
Nitrogen 0·217 „
Organic matter 5·71 per cent.
Ash 5·74 per cent.
K_2O ·29 per cent.
CaO 2·218 per cent.

Two samples—Trash and weeds.

	1st sample. Per cent.	2nd sample. Per cent.
Moisture	68·34	67·82
K_2O	0·4262	0·2633
P_2O_5	0·3806	0·296
Nitrogen	1·0076 (dry sample).	0·655 (dry sample).

Two samples—Water Hyacinth (Dacca Farm).

	1st sample. Per cent.	2nd sample. Per cent.
Moisture	70·35	58·87
Ash	12·75	6·00
Sand	12·22	34·96
K_2O	0·32	0·51
P_2O_5	0·28	0·16
Nitrogen	0·26	0·21
CaO	0·30	0·20
MgO	0·12	0·20

Six nitrogen estimations of compost made from threshing floor litter and weeds

Nitrogen— 0·4, 0·51, 0·32, 0·34, 0·37 and 0·35 (moist basis).
„ 1·02, 0·97, 0·60, 1·15, 0·60 and 0·54 (dry basis).

Two samples made from refuse in the compound of the Director of Agriculture, Bengal :—

	1st sample. Per cent.	2nd sample. Per cent (Calculated on air dry basis.)
Moisture	41·76	44·08
Loss on Ignition (without moisture)	18·58	19·96
Sand	30·22	26·52
P_2O_5	0·90	0·93
K_2O	1·09	1·02
Nitrogen	0·96	0·95

Two average samples of Cowdung :—

	1st sample. Per cent.	2nd sample Per cent.
Moisture	72·55	77·07
Ash	13·0	7·79
Sand	10·03	5·45
Organic matter	14·4	15·14
Nitrogen	0·47	0·45
K_2O	0·44	0·31
CaO	0·29	0·37
P_2O_5	0·49	0·32

Latterly, other nitrogenous substances have been used in making artificial farmyard manure. Ammonium sulphate, with bone, and Ammophos, without bone, both supplied by Messrs. Shaw Wallace & Co. of Calcutta, are two of these. Cowdung mixed in about 20 times its weight of water is a third. The cowdung gave very satisfactory results.

With ammonium sulphate (0·5 per cent. solution) and bone, comparatively refractory material, such as dried teak leaves, has undergone quite satisfactory fermentation in four or five months. So far, however, as was indicated by the preliminary laboratory experiments, no nitrogenous substance used produces such rapid and satisfactory results as urea, diluted cattle urine, or cowdung and water. Urea is now being manufactured commercially in Europe and arrangements have been made to import enough for a comprehensive test. In the meantime, it is sufficient that for the cultivator who, for any reason, has not sufficient cattle urine or cowdung, ammonium salts with bone, applied as already described, make a quite good substitute.

It will be seen from the few analyses quoted that the composition of the fermented material varies a good deal. This is only to be expected, since every heap of manure that is made, is compost either of different starting materials or of different percentages of these. Also the analyses were taken at different times of the year which must always affect the results somewhat: thus heavy rains are bound to cause a certain amount of leaching of the more soluble constituents if care is not taken to prevent it. The nature of the residue after fermentation has taken place is

important. The material, if care is taken when building the heap, presents an appearance of well rotted cowdung, being dark-coloured and easily broken up into a dark powdery substance. The residue obviously approximates to humus which is known to be an important organic constituent of all soils. One important point should be noted in the building of the heap for fermentation, *viz.*, that every foot of material should be carefully treated, particularly with regard to the liquid manure. Too great care cannot be taken in seeing that the liquid manure is evenly spread over the whole : more than once it has been noted that the liquid has been carelessly thrown on the heap and that only the part treated is rotted, while the remainder is more or less unaffected.

Extensive enquiries throughout Bengal, a few years ago, elicited numerous replies to the effect that lack of manure and the cost of weeding are two serious impediments in the way of successful agriculture in the province. The method described above indicates how weed taken from the fields, and other otherwise useless organic matter, can be used to make a valuable increase in a cultivator's manure supply ; also that, in most cases the realization of this increase involves the use of nothing which is not available on the homestead.

It has also been found that phosphate of ammonia which has recently come on to the manure market in various forms is an excellent " starter " in the manufacture of artificial farmyard manure and that it is an efficient substitute for ammonium sulphate plus bone meal or for cattle urine and bonemeal.

AN ECONOMICAL METHOD OF MANURING WITH SANN-HEMP.*

BY

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GREEN-MANURING as a means of improving the fertility of the soil has been practised in many parts of India, and where it was unknown it has been recommended by the Agricultural Departments, so that the benefits resulting from the ploughing in of a green crop in the soil are now well known to agriculturists. Experiments conducted to ascertain the cost of manuring in various ways have further shown that the quantity of nitrogen added to the soil per acre in green-manuring is obtained more cheaply than an equal quantity supplied through artificial manures like sodium nitrate or ammonium sulphate, and compares favourably with organic manures like oil-cakes, and hence the practice of green manuring has been confidently recommended to the cultivators.

Everything being thus favourable, the practice of green-manuring as a means of fertilizing the soil should be expected to be very much more common than it is at present. Owing however, to the rains being limited to one season instead of being well distributed over the whole year, in many parts of India it is found uneconomical to have to lose the whole season which is required to grow the green-manure before burying it in the soil. There is no money return for the season during which the green manure is growing. It would be a great advantage therefore if some crop for green-manuring could be found which would also yield some money return for the season during which it is grown, before being buried in the soil. The money return that could be expected from a green manure crop during the season in which it is grown may result from some use being found for those parts of the plant which are useless for manurial purposes. It is essential therefore to find which part of the green crop is useful for manuring, so that the portion useless as manure may be turned to some use by the cultivator. Four green manures were chosen for this enquiry and in a paper read before the Science Congress in the year 1919 the results of work previously done on the subject were described. It was found that the leaves of the green manures supply the major portion of the fertilising material (nitrogen) for the succeeding crop. In the present paper it is proposed to deal with one of the four green manures, *viz.*, sann-hemp (*Crotalaria juncea*). This green manure has given promise that it can be utilized as a double purpose crop for green manure as well as fibre at one and the same time, provided the old method of ploughing in the whole plant in the soil is changed to ploughing in only the tops of the green manure leaving the stems for use as fibre.

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* Paper read at the Indian Science Congress, Lahore, 1927.

Before proceeding to discuss how this is possible, it would be useful, however, to give a short summary of the conclusions arrived at by the present writer in his previous investigations on this subject in order to see how the idea of the experiments described in this paper originated. As the green manure after being incorporated into the soil is subject to the action of micro-organisms, investigations were carried out to determine how this biological action proceeds in the case of the different parts of the plants and also what effect the additions of different parts have on the succeeding crop. It has already been shown :—

(1) That the leaves form about 50-60 per cent. of the weight of the green-manuring crop in the earlier stages of the growth. At later stages, owing to the fall of the older leaves and the increase in weight of stems, they form about 25-30 per cent. of the weight of the whole green manure crop.

(2) That the leaves decompose earlier than the other parts (stems and roots) of the plant or the whole plant.

(3) That decomposition of the green material takes place most rapidly and large quantities of nitrates (as compared with its original amount in soil) accumulate when the moisture content is about 16 per cent. of the weight of the soil.

(4) That the weight of a green manure crop added to the soil varies greatly in different seasons.

(5) That the immediate effect of green-manuring on a succeeding crop is principally due to the leaves of green manure crops. This was found as the result of experiments to test the growth of a crop after green-manuring with the leaves, stems and roots each in a separate plot. The yield of oats after treatment with different parts of cow-pea and sann-hemp as green manures are given in the following table :—

Treatment	Yield of oats					
	1919-20		1920-21		1921-22	
	lb.	oz.	lb.	oz.	lb.	oz.
Control	0	13	5	4	4	0
Cow-pea—						
Whole plant	1	2	6	12	4	14
Leaves	1	7	6	12	6	3
Stems	1	0	6	0	4	2
Roots	1	0	5	12	3	13
Control	..		2	8	3	4
Sann-hemp—						
Whole plant	..		3	4	3	9
Leaves	..		5	0	5	10
Stems	..		3	8	2	9
Roots	..		2	8	1	5

More or less similar results were obtained in the case of other two green manures, *dhaincha* (*sesbania aculeata*) and *guvar* (*cyamopsis psoralioides* so that it wa sevident that the addition of the whole plant of a green manure crop tends to lower the yield of the succeeding crop as compared with the addition of leaves of green plants. Experiments in subsequent years have confirmed this, as may be seen from the following table which records results for sann-hemp only. The results for other green crops being practically repetitions of similar figures are not included here.

Treatment	Yield of oats							
	1922-23		1923-24		1924-25		1925-26	
	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.
Control	4	10	3	4	3	4	3	7
Sann-hemp—								
Whole plant	4	4	4	11	3	11	5	0
Leaves	4	10½	4	11	5	0	6	4
Stems	4	8	1	14	4	10	2	9
Roots	3	5	0	14	4	10	2	6

As seen from these results, the leaves of the green manures are the principal beneficial factor in affecting the yield of a subsequent crop, and a green crop, therefore, whose stems could be utilized for some other purpose, after stripping it of leaves for green manure, would naturally be of great importance. Of the green manures selected in our experiments, sann-hemp is such a crop which is already grown specially for utilizing its stems for fibre. It would be an advantage therefore to use its leaves for green manure and its stems for fibre at one and the same time. A further advantage in the case of sann-hemp is that when the leaves alone are to be turned in the soil (as they decompose much earlier than the whole plant) the crop can be allowed to grow according to season, three or four weeks more than if the whole plant were to be ploughed in. This would give not only a greater amount of leaf but the stems would be by that time more mature and yield better fibre.

Experiments on a larger scale than those carried out previously were therefore started to determine the effect of burying the whole plant and leaves alone of sann-hemp at different times. Each plot in the e experiments was 825 sq. ft. in area (approximately 1-50th of an acre), there being four such plots generally available for each kind of treatment. The addition of leaves to the soil was done once, at the usual time of burying the whole plants in the soil, and compared with the addition done three weeks later. Whole plant was buried at the time usual for turning in the green manure, as at a later stage it would not be completely decomposed before the time of sowing the succeeding crop. Oats were sown after the added green-material had undergone decomposition in the plots. The yield of the whole plant

and leaves, with their nitrogen content and the fibre obtained from the stems, is given in the following table :—

Treatment	9 weeks' growth Yield of four plots (1-13th of an acre)			12 weeks' growth Yield of four plots (1-13th of an acre)		
Sann-Hemp—	mds.	srs.		mds.	srs.	
Whole plant	16	12	(0·4% N.)	24	0	(0·35% N.)
Leaves	5	1	(0·98%)	6	26	(0·84%)
Fibre	0	13		0	20	

The yields of different plots range within narrow limits and hence only the average yields of oats grain and straw calculated on an acre basis are given in this paper.

Green manure	N. added per acre	Yield of oats			
		Grain per acre		Straw per acre	
	lb.	mds.	srs.	mds.	srs.
Leaves—9 weeks crop	51	16	15	33	21
Leaves—12 weeks crop	59	16	27	35	21

The average yields of oats per acre are given for the whole plant and leaves in the following table :—

Treatment	N. added per acre	Yield of oats			
		Grain per acre		Straw per acre	
	lb.	mds.	srs.	mds.	srs.
Whole plant—9 weeks	78·0	25	39	52	35
Leaves—9 weeks	51·0	24	20	56	13

It will be seen from these results that the effect of leaves of the green manure on the yield of grain is less than that of the whole plant. This is contrary to the results on small plots. The yield of straw on the treated plots, however, is greater in the case of leaves than that obtained from those treated with the whole plant.

This is due to the greater fertility of the land in which these experiments were carried out. This perhaps requires some explanation. The plants at the start were very vigorous in the plots manured with leaves and continued to be so to the end, but owing to this very reason they lodged during the heavy rains received towards the end of February and beginning of March. The vigorous plants generally require to be topped in such cases, but it was not done in this case as it would have introduced an unnecessary complication in judging the results. The yield of grain was consequently less from the lodged plants. This can be noticed from the amount of straw obtained from the plots treated with leaves as compared with that obtained from those treated with the whole plant. The results of leaves added at different times are, as expected, in favour of the later cutting. The sann-hemp stems stripped of leaves have given material yielding about 4½ mds. fibre at nine weeks' cutting and 6 mds. at twelve weeks' cutting as can be seen from the following table. The extra cost for getting this material is the labour involved in separating leaves. This amounted to Rs. 15 per acre as ascertained from the payments made to hired labour. No doubt the cultivator if he were doing it in his own field would do it more cheaply. However, as the quantity of nitrogen supplied by the addition of the whole plant and of the leaves alone as manure did not make much difference in the yield of the succeeding crop, it was necessary to try some cheap means of separating the leafy portion in order to supply the necessary nitrogenous material. Since in using the sann-hemp for fibre it is usual to cut off the tops in this part of the country it was proposed to utilize these tops by cutting them in such a way as to include as much of the leaves of the plant as possible for green manuring and to compare this with treatments of the whole plant and of leaves. This idea occurred after the expenses incurred in the separation of leaves were noticed for two years, and hence the treatment with tops was done at the later stage of our period of experiments, *i.e.*, when separating the leaves only in 1923-24. The extra cost of cutting the tops is found not to exceed Rs. 2 to Rs. 3 per acre. The results of these experiments are given in the following table :—

	1923-24 Yield of green manure in four plots ($\frac{1}{13}$th of an acre)					
	9 weeks and 3 days			12 weeks and 6 days		
Sann-hemp—	Mds.	srs.		Mds.	srs.	
Whole plant	26	20	(0·4% N.)	29	20	(0·34 %N.)
Leaves	10	32	(0·98% N.)	10	0	(0·843 %N.)
Tops	....			4	5	(0·81% N.)
Fibre	0	13		0	20	
	(=4½ mds. per acre)			(=6 mds. per acre.)		

Outturn of oats

Treatment	Nitrogen per acre	Grain per acre		Straw per acre	
	lb.	mds.	srs.	mds.	srs.
Leaves—9 weeks and 3 days	104·0	10	32	20	15
Leaves—13 weeks and 6 days	102·0	11	5	22	27
Tops—12 weeks and 6 days	34·6	11	2	19	35

From the weight of the whole plant given in the table, it may be noticed that the sann-hemp crop this year was very heavy. It may also be noticed that the leaves obtained at the second cutting has not increased proportionately. This is due to the shedding of leaves between the first and the second cutting. This shedding of leaves generally takes place after the first cutting and depends on the season and growth of the plants. Although we are not able to give a quantitative value to it, still the soil receives it all the same. It only means that the figures for nitrogen (added per acre), as given in the tables, are smaller than what they actually would be, if the nitrogen in the fallen leaves could be accurately determined and added to the figures already given.

As regards yields of grain, it may be noted that the tops have proved practically as effective as the leaves and that the results are slightly in favour of later ploughing of leaves and tops. The later cutting, however, shows 50 per cent. gain in the quantity of fibre over that obtained from the earlier cutting. As it was now clear that the tops of sann-hemp when buried in the soil are more or less as effective as the leaves, in the next trial the addition of tops was done at different times as also burying the leaves at different times and the results are given in the following table which speaks for itself :—

Treatment	1924-25 Yield of green manure of four plots (1-13th acre)					
	10 weeks			13 weeks		
	Mds.	srs.		mds.	srs.	
Sann-hemp—						
Whole plant	16	1	(0·38% N.)	24	0	(0·35% N.)
Leaves	10	2	(0·84% N.)	10	26	(0·70% N.)
Tops	2	30	(0·75% N.)	3	38	(0·65% N.)
Fibre	0	8		0	12	

Yield of oats

Treatment	10 weeks					13 weeks				
	Nitrogen added per acre	Grain per acre		Straw per acre		Nitrogen added per acre	Grain per acre		Straw per acre	
	lb.	mds.	srs.	mds.	srs.	lb.	mds.	srs.	mds.	srs.
Leaves	56·0	23	0	33	3	72	24	8	31	33
Tops	20·0	26	4	35	10	25	26	8	33	26

No doubt the difference in fertility of the soil in the plots may have to do something with the greater yield which is noticeable in the case of tops although the nitrogen added to the soil was actually less than that added in the form of leaves. In any case as difference in the yields is not commensurate with the additional cost involved in completely separating the leaves, it was not necessary to continue separating the leaves and in the following year an experiment with burying the tops only at different periods was tried. It was also proposed to push the period of cutting the tops still further by about three weeks in each case so that the first cutting was done when the sann-hemp was thirteen weeks old and the second cutting when it was sixteen weeks. The reason for this change will be discussed later. The results appear in the following table :—

	1925-26 Yield of green manure of four plots (825 sq. ft. each)					
—	13 weeks			16 weeks		
Sann-hemp—	Mds.	srs.	ch.	Mds.	srs.	ch.
Whole plant	16	11	(0·34 % N.)	17	29	(0·32% N.)
Tops	3	4	(0·72% N.)	3	24	(0·72% N.)
Fibre	0	12	6	0	12	10

Oats

Treatment	Nitrogen added per acre	Grain per acre		Straw per acre		Fibre	
	lb.	mds.	srs.	mds.	srs.	mds.	srs.
Tops of Sann-hemp at 13 weeks . .	22·0	6	28	14	0	3	35
Tops of Sann hemp at 16 weeks . .	25·0	7	6	13	13	4	0

In addition to these trials, which were conducted during the last four years two more experiments on several larger plots (1-24 of an acre each) were carried out with oats and wheat for comparing the two treatments, *viz.*, the addition of tops and the addition of the whole green manure. The soil was manured with a phosphatic fertilizer in the previous years.

Treatment	Oats		Wheat	
	Grain per acre		Grain per acre	
	Mds.	srs.	mds.	srs.
Tops	18	24	9	21
Whole plant	18	3	8	28

It will be seen from the results obtained during all these years that the usual practice of ploughing in the green manure 8-10 weeks' old could be replaced by manuring with tops cut from the green crop (12-14 weeks' old). No doubt the nitrogen added to the soil by the burying of tops appears smaller, but this is supplemented by the nitrogen added in the form of leaves dropping during the further period of growth allowed before the tops are cut. In any case while the yield of the succeeding crop after burying in the top portion of green crop has not been lowered, the yield of fibre from stems amounts to 4 to 6 maunds per acre at an extra cost of Rs. 2 to Rs. 3 per acre.

In the course of these experiments it was of interest to record that when the whole plant was ploughed in as green manure, the succeeding crop suffered damage from white ants in certain plots on account of some portions of woody stems remaining undecomposed in the soil and such area had to be measured and left out of consideration in calculating the crop per acre; otherwise the balance would have been still more in favour of treatments with leaves and tops, which had no trouble from white ants as all the material added in this latter case was completely decomposed.

It was pointed out to the writer that the fibre from sann-hemp if cut earlier would be weak and therefore would not secure the price that the mature fibre fetches. It may be mentioned, in this connection, that the sann-hemp is cut for fibre in Bihar by the beginning of October when it has grown for about 15 to 16 weeks. In the earlier years of our experiments the second cutting was done in the 13th week from sowing sann-hemp, that is, the cutting for fibre was earlier by about two weeks only. The experiments in the last year 1925-26 have further shown that there is not much difference in the amount of fibre obtained by cutting the sann-hemp in the 13th week and cutting it in the 16th week, showing thereby that the fibre

practically attains its maximum growth up to the 13th week. Moreover, when offered in the local market, both fibres fetched the same price. The time of cutting the tops for manuring should therefore depend upon the time necessary to allow for decomposition of the green material added to the soil before sowing the succeeding crop. The tops and leaves decompose practically completely in three to four weeks after being ploughed in.

In this connection it may be worth mentioning that sann-hemp is recommended to be grown and the whole plant to be ploughed in for sugarcane in Bihar. The field for sugarcane would be required much later than the usual *rabi* crops like wheat or tobacco as the sugarcane is planted in February and hence there is enough time in this case both to allow the sann-hemp to grow to the usual time for cutting for fibre, manure the land with tops of sann-hemp and to get the fibre from the stems which are practically of no value as manure.

Further, in manuring with the tops of the green crop these can be transferred and spread on any area at will, so that they can be concentrated on an infertile patch of land or sparingly spread on fertile land as required. This is not done when the green crop is ploughed in where it has grown.

AGRICULTURAL IMPLEMENTS SUITABLE FOR THE USE OF THE INDIAN CULTIVATOR.

BY

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(Concluded from Vol. XXII, Pt. 6.)

It is necessary to discuss certain general principles which apply equally to ridge ploughs and ordinary mouldboard ploughs, and firstly to insist on the vital importance of reducing the length to the minimum possible, by the use of pole draft. Undoubtedly, one important reason for length in ploughs, and particularly ridge ploughs, is ease of steering. In the West it is a matter of efficiency and pride to make furrows as straight and parallel as possible, and the total length of the implement aids greatly in this. In India and the East generally, however, the cultivators' plots are so small that the control that can be obtained by differences in side pressure on the two sides of the plough by lateral movements of the handle, is amply sufficient to give the straightness requisite in the short furrows obtainable. We all know the uncanny precision with which a ryot can steer his country plough, simply because a slight sideways movement of the handle increases the pressure of the soil on one side of the plough and causes this to slide slightly in the opposite direction. With a mouldboard and even more so with a ridge plough, steering by side pressure only is equally simple, and length is entirely unnecessary under Indian conditions.

The axiom that the price must be as low as Rs. 10 is complicated somewhat by consideration of the relative merits of castings and forgings for this work. The separate parts of ploughs are body, share and point, mouldboards and landslide ; and all can be either cast of suitable metal, or forged. Castings must be comparatively thick and heavy ; but the wearing parts can be made very hard, and therefore very long wearing. They can be produced in quantity with a minimum of hand labour, and so their cost need be little more than the cost of the metal ; and they can be so standardised as to be entirely interchangeable, so that the supply of necessary spare parts is simple and cheap. But the ploughs and their spares must be produced in a properly equipped factory. Forged ploughs and their parts can be made much lighter, but cannot be so hardened and therefore have a much shorter wearing life. Also every part and spare entails a certain, often very considerable, amount of hand labour, so that their cost will necessarily be higher ; and standardisation is much more difficult, if not impossible. On the other hand,

spares and even whole ploughs can be made in every bazaar, and even by the village blacksmith. My own view is that cheapness, long life and easy supply of spares, are conclusive arguments in favour of cast ploughs ; but I can quite understand advocates of the revival of village industries thinking otherwise, though whether the revival of these industries is for the good of the cultivator is another matter.

Every plough sold in India should have a detachable point, because under the conditions under which it is used the wear on the point is very heavy and the life of the point, particularly in some, *e.g.*, laterite soils, very short. In any soil the proper life of the share generally is about 10 times that of its point ; and the provision of a cheaply renewable point is essential to avoid waste of a large number of shares rendered useless because the point has gone, and to save wear on parts of the body which become exposed to friction when once the point of the share is worn. I have seen Meston ploughs being ruined because the owner could not bring himself to face the cost of a new share costing As. 12 or As. 14, and the waste of such a large piece of the old one ; when the under parts of the body were being badly worn and the plough could hardly be made to work at all. The Victory is another very fine plough, but the share costs Rs. 4-4 in Calcutta and has no detachable point. A detachable point is an absolute essential for any plough sold for the use of the Indian cultivator, but the question arises as to whether the point should be a cast, slip in, nose of the share, or a bar which can be slid out to compensate for wear, and on which finally a new piece can be welded, giving it practically limitless life.

Cast points can be made to slip into the share either way up, so they can be turned after slight wear ; and they can be case hardened to give them a very long life. In quantity they need not cost more than As. 3 each, and fitting them does not add anything to the cost of the rest of the plough. Against this must be set the fact that only about ½ the metal in them can be used and the rest must be discarded. A bar point has to be much longer and heavier to begin with, to allow for rigid fixing ; and so the first cost is much higher. It cannot be so hard, and so wears more rapidly ; and whatever device is adopted for fixing and adjusting it, must add appreciably to the cost of the plough body. On the other hand, nothing of the bar need ever be wasted ; as, when the bar is worn too short for further adjustment, a new piece can be welded on by the village blacksmith. A recent price list quotes cast points of different ploughs at As. 6 and As. 7 each, while the cheapest bar point for that type of plough is quoted at Rs. 1-12. Again I give my opinion that low first cost, long life, and simple fitting are conclusively in favour of the cast, slip in, point.

A final general principle of vital importance to cheapness and standardization is the need to discard all theories of requiring different ploughs for different soils and different work, and to concentrate on one compromise type that will do reasonably satisfactory work under the wide range of conditions encountered. In Europe, where ploughing, through centuries of practice, has become an art, and the careful

burial of long manure or the thorough turning and covering of an old turf are matters of great skill and pride, there is undoubtedly great scope for a number of differing types of plough to get perfect ploughing under the wide range of soil conditions and in different kinds of work. In a century it may be so in India also : but at present ploughing is merely digging up the earth ; and, before he can learn to plough perfectly, the ryot has still to learn to plough, instead of to scratch ; while often the soil conditions in a holding vary as much as in a western country. In Chota Nagpur, for example, the soil of a single holding generally varies from very sandy loam to very heavy clay ; while even on the famous Ganges alluvium, one holding will generally contain soils ranging from light loam to medium clay. But one plough will plough them all, if taken at the right time and in the right condition ; and though the ploughing is not perfect, it is sufficiently in advance of the scratching the soil usually gets to be an improvement very well worth while.

It is wise therefore to save overlapping, waste and confusion, by concentrating on just one model each of plough and ridge plough, and have this built for pole draft, of cast parts and with a detachable cast point.

The Ridge Plough.

This is only used for opening furrows in which to plant, or in earthing up crops to improve drainage and help them to stand, so it is always used in prepared land, *i.e.*, a prepared seed-bed or in rows that have already received some cultivation. It can be therefore comparatively lightly constructed. But as its use is largely at times of the year when weeds grow rapidly, I advocate strongly a wide flat cutting share that will skim from the furrow bottom a ribbon of earth, weeds and grass, and split this to its mouldboards, which should in turn slide the earth up and over to form the ridges, well in the middle of which such weeds and rubbish will be safely buried. The common type of English ridge plough, with its long bar point and comparatively straight sloping mouldboards, which burrows through the earth and pushes the soil to a ridge on either side, is not, I think, suitable for ridging tropical soils. For our work a ridge plough must be essentially a duplication of a short-breasted mouldboard plough.

As, however, the ryot will want in the winter to earth his potatoes and in the summer his maize, cotton or cane, his plough must throw varying widths from 18″ to 36″. This can, I think, best be obtained by hinging the mouldboards. A bent piece of simple angle iron provides a cheap body. Below is bolted the cast share with its slip in point and above a short, cast, splitting breast, on the rear of each wing of which are cast the simple hinge device. The mouldboards hinge to these, and are supported at any width by simple stays to a central tail running back from the middle of the frame iron. The pole bolts at an angle to the top of the frame iron and the end of the tail and the handles can be attached at similar points. A simple skid can be fixed below the tail piece for transport and steadying when at work.

In the one illustrated the angle between body iron and tail piece has been carefully adjusted so that the pole and handles can be fixed as shown, or the plough can be sold without pole and handles. In the latter case it is fixed by three bolts to the front vertical bar of the Bihar cultivator, all tines being removed from this, and the owner is saved the cost of a separate pole and set of handles, a small economy which is a big matter to the Indian ryot.

The Plough.

People who work much among the cultivators generally understand that the Indian plough bullock always turns to the left and never to the right. This is one of the apparently simple obstacles one meets and dismisses lightly, but can never surmount ; because, no matter how well trained our farm bullocks and ploughmen are, nor how well, under our eye, the cattle turn right or left as required, no sooner do the men and cattle get away to their own or a cultivator's field than they turn left at once and all the time. On our land the responsibility is ours and the danger also ; but on their own land they take no risks, but believe in " safely first " and their cattle turn only to the left.

In small plots with cattle turning left, inevitably ploughing is done from the outside to the middle if the plough allows ; and a mouldboard that throws to the right not only allows but encourages this. So Indian cattle and a right hand throwing plough ploughs the fields outwards time after time, till the centre is a hollow and the edge a containing rim ; and the consequent waterlogging and deterioration of the soil is laid at the door of the English plough, and we are told in all seriousness that an English plough spoils the land.

This is one of the eastern customs which many have tried to break and all have failed and will fail, at any rate for a few more centuries, and the only sound way to deal with it at present is to accept it and supply a plough to suit it. As far as I know, there is no difference whatever between a plough throwing right and the same plough built to throw left. Produced on the same scale, one is as cheap as the other ; and the work done by both is the same, if equally intelligently used. But with bullocks that turn to the left, a right throwing plough is never intelligently used ; while a left-throwing one can only with difficulty be used otherwise. For India, therefore, all mouldboard ploughs supplied should be left handed, to turn earth to the left ; and with them the ryot will find it very difficult to do other than plough his plots up to the middle, with consequent improvement of drainage and crop bearing capacity. This is the first and fundamental consideration to be kept in mind.

The second is the necessity for some form of compensation for the difference between the furrow width and the draught width. We all know that ploughing is a slow, laborious process, that costs heavily in proportion to other agricultural

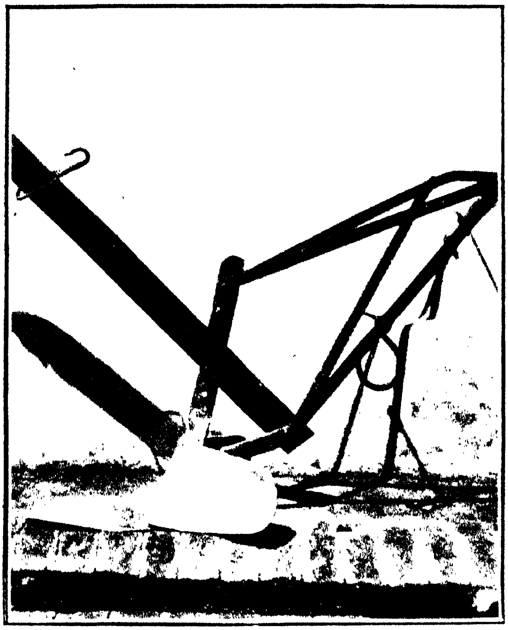


Fig. 1.

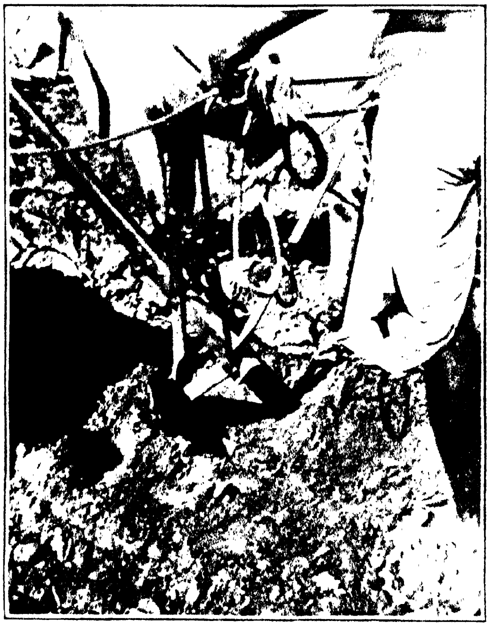


Fig. 2.

Fig. 3.

Fig. 4.

operations ; but that if done thoroughly, it is well worth while because at one operation the whole bulk of earth to the depth we are working is cut off from below, thoroughly shaken and broken, and turned over on the top of weeds and rubbish. One ploughing is the equivalent of 6 or 8 " chases " with the country plough or of 2 or 3 cultivations. But only if it is done properly.

For a mouldboard plough to plough properly it must tend to run with its share flat across the bottom of the furrow being cut, at an even depth, and in a direction parallel to the last furrow, at a distance generally of 7 or 8 inches from it. For work with cattle in small plots we have already decided (*Vide Agri. Journal of India*, Vol. XXII, Part IV, pages 288 and 289) that short pole draft is essential ; so that little steering control is possible without sideways tilting ; and such tilting must be avoided if feasible, as only when the plough is running flat and true is it doing its proper work. The first step obviously is to get the cattle to move in exactly the right direction and parallel to our furrow. There is only one line to guide them and that is the last furrow. On one side of that is a mass of clods and loose earth over which the bullock will wander in any direction but the right one, and on the other is the unploughed surface, generally a mass of weeds and rubbish. We must therefore make one bullock go in the furrow, when the other will keep his distance on the unploughed land. Any plough bullock will go quietly along a furrow with very little coaxing, though I defy anyone to drive a pair of ryots' bullocks straight along a given line, without that furrow to guide them.

The common plough yoke of India is 4 to 5 ft. long and the common distance between the necks of the bullocks is 40 to 48 inches. Half that, which is the distance from the neck of the furrow bullock to the centre of the yoke, where the plough is hitched, is 20 to 24 inches. But a plough furrow is only 7″ to 8″, rarely 9″ wide ; so that though the hitch is 20″ away from the last furrow, the plough must not be more than 9″, a difference of 11″ between draft width and furrow width. In western ploughs this difference is taken up partly by the length of beam and chain, and partly by the hake set across the end of the beam ; but our draft must be a short pole and the hitch on the yoke only 6 or 7 feet from the plough.

There is commonly used on Bihar plantations a cheap copy of the old Hindustan plough which has short pole draught and of which the pole is directly over the landslide of the plough. When the bullock is in the furrow the plough tries to be 18″ away, and is forced back to the furrow by tilting it over on to its landslide, to the detriment of the ploughing. Then the bullock swings away on to the land and the plough comes back into the last furrow. Not for 2 minutes together is the plough running square and true in its proper place and doing its proper work, because when the bullock is in the furrow, the only guiding line, the plough is too far away from it.

Some simple form of offset device is required on the plough, so that the pole is attached 8″ or 9″ sideways from the landslide, as shown in Pl. XI, figs. 3 and 4.

The bullock is in the last furrow, the yoke hitch is 18″ to the right, the pole is parallel to the work, and the plough 9″ to the left of the base of the pole, is in its true position for easy and proper work. Without some such offset no mouldboard plough with short pole draught can be made to do good work ; and ploughing, unless reasonably well done, is not worth doing. A few cultivations are simpler and cheaper.

It is possible to take up this difference between ploughing width and draft width by setting the pole at a small angle to the line of the plough ; but this method is unsound because a lengthening or shortening of the hitch on the pole, to suit higher or lower bullocks or to plough deeper or shallower, alters also the width of furrow taken ; and with large bullocks a narrower furrow is taken than with small ones, the reverse of what would be desirable. The pole should be parallel to the line of the plough, but 9″ to the side of it ; and it is desirable to make this offset simply adjustable so that, for transport along roads, the offset can be closed up, the yoke brought back along the pole to lift the share and point off the ground, and the plough slid home on its heel lying snugly between the heels of the bullocks.

It is most important to make the offsett attachment an integral part of the body of the plough. Normally, all such ploughs are sold in the *Dehat* without woodwork, and the construction of the plough body should be such that the pole can only be attached in one obvious way ; as, if the ryot is left any choice as to how the pole can be attached, he is certain to make the wrong choice. One cannot be too careful to make such a device absolutely fool proof, as even on Government farms it is common for an implement to be put together wrongly if such a course is possible, and then it is often condemned without a fair trial.

It will be remembered that in discussing the ridge plough I suggested that such a plough might be sold, without handles or pole, to be fastened to the front vertical column of the Bihar $\frac{3}{5}$-tined cultivator. Similarly, the single mouldboard plough might well be constructed to bolt firmly to the left side bar of the frame of that cultivator. Two holes in the plough frame in a horizontal line, to register with two corresponding holes in the cultivator frame side member, and an extra vertical piece bolted firmly to the body of the plough and passing up and in, to the bolt where the pole and handles cross, provide an attachment rigid vertically and longitudinally. The cultivator frame itself provides the required offset. I have tested thoroughly such a plough and find it quite a practical outfit ; and again it is thought that the saving of pole and handles so possible, would be thoroughly appreciated by the ryot.

A final point apparently not generally appreciated is that the downward pressure on a plough point, *i.e.*, the pressure that makes the point dig itself into the ground, is less when the plough has short pole draft than when it has the usual beam and chain draft. To compensate for this, in any plough sold for use with short pole draft, the angle which the share and point makes with the line of the bottom of the plough, generally the lower side of the landslide, should be very

appreciably greater than is usually the case ; otherwise the plough must be run on its nose, and the tail of the landslide and the rear of the mouldboard will be up out of the earth and the plough will not sit in the furrow securely nor turn the earth properly.

The writer advocates the following essentials for any plough to be marketed for the use of the Indian ryot :—

(1) Cheapness to be obtained by the use of light castings throughout.
(2) A detachable, invertible, slip in, cast point.
(3) Pole draft.
(4) Left hand throw.
(5) An offset device either (*a*) integral to the body of the plough whereby the pole is attached parallel to the line of the plough but 8″ or 9″ to the right of the landslide, or (*b*) obtained by bolting the plough rigidly to the left side bar of the Bihar $\frac{3}{5}$ tined cultivator.
(6) An abnormally steep set of share and point.

Apart from these, such a plough should be of the short breasted, wide throwing, breaking, type, capable of ploughing reasonably well any class of land from sandy loam to heavy clay, and it will then meet sufficiently well the requirements of the whole country. Two sizes are advisable—

(1) About the size of the Punjab plough for tracts where bullocks are large and for estates, Government farms,etc.
(2) About like the Meston, for the paddy tracts and other areas where bullocks are small.

No. 1 would plough 6 or 7 inches deep and 8 or 9 inches wide and No. 2 about 4 to 5 inches deep and 5 or 6 inches wide, but the same body, offset and landslide, and point would suit both, the only difference being that No. 2 would require a narrower share and correspondingly narrower, though just as wide throwing, mouldboard.

Summary.

As these articles have been spread over four numbers of this Journal, I may be forgiven for summarising not too briefly the points at issue and the measures recommended.

We, as workers for the improvement of Indian agriculture, are really concerned very little about the merits of different tractors, or whether a reaper and binder can be used in India and the cost of threshing wheat with a Marshall's outfit ; because these, and such costly and complicated machines, are utterly and absolutely beyond the scope or range of 99·99 per cent. of the cultivators of this land. What the ryot wants is some small, but sound improvement, that can be incorporated into his present conditions of living and working ; and not a big thing that demands first enormous capital, large holdings or their equivalent, mechanical sense, in short

the conditions of Australia or Western America. His small scattered holdings, tiny plots, poor bullocks, intense poverty and utter lack of mechanical knowledge, are conditions we must accept; and, facing them, concentrate on those improvements, *e.g.*, better seed, new manures, etc., that can be adopted into those conditions and which, once accepted by that 99·99 per cent. of typical cultivators, bring enormous aggregate good to the country as a whole.

This is as true of implements as of other lines of improvement; and our first and most pressing duty is to try and supply simple and cheap equipment, that can be adopted into the present system of cultivation, but will profit the ryot by enabling him to do better and more varied cultivation, with less expenditure of labour of man and beast. The implements outlined in the foregoing pages fulfil these conditions in that they are cheap, adapted to bullock draft and small plots, and mechanically simple.

The Bihar cultivator, either in the simplest 3-tined form for tracts where bullocks are small, or in the $\frac{3}{5}$-tined form for tracts where bullocks are large, will do, faster and cheaper, all the work done by the country plough; and will, in addition, intercultivate and partly ridge up crops grown in lines. From the extraordinary utility of this implement on our farms at Sepaya and at Sewan, and the interest shown in it by local cultivators—six have already been sold and I have a small waiting list of people who have each deposited Rs. 2, to ensure getting one—I judge that the Bihar three-tined cultivator, if marketed on a sufficiently large scale to be really cheap—at present we are quoting Rs. 10 to Rs. 15—has a real chance of rivalling the country plough in its appeal to the general mass of cultivators. The firms so far interested are Messrs. Arthur Butler & Co., of Muzaffarpur, who have made a very simple and, I think, sound three-tined boltless model, the Saran Engineering Co., Marhowrah, Saran, and Messrs. D. N. Ghosh & Sons of 84-A, Clive Street, Calcutta, who have supplied me copies of the $\frac{3}{5}$-tined model; and all these firms would, I know, welcome enquiries.

The Bihar ridge plough enables the ordinary bullocks to be used to open up furrows for planting cane, potatoes, etc., and to earth up maize, cotton, cane, potatoes, etc., and eliminates the *kodali* (spade) from this class of work. So far only the small size with fixed mouldboards to throw ridges $2\frac{1}{2}$ feet wide is available; and that can be supplied either complete, or for fitting to the cultivator, by Messrs. Arthur Butler & Co., Muzaffarpur.

The Bihar plough enables the cultivator, even with small bullocks and in small plots, really to plough his land. Messrs. Arthur Butler & Co., have supplied me with the experimental model of which photos have been shown, and are now making samples of a production model based on this and likely to be very satisfactory. They will, I know, welcome enquiries on this also. I owe them my grateful thanks for their very valuable assistance in supplying the experimental models on which to test the various, somewhat new, requirements I have detailed in the section on ploughs, left throw, offset, and steep point and share; and I hope any one

interested in obtaining ploughs, cultivators and ridge ploughs, really built for work under the peculiar conditions of this country, will give this firm a trial order.

Whenever the improvement of Indian agriculture is discussed we are met by the same vicious circle, poor cattle, poor tools, poor crops, little money, little fodder and so round to poor cattle again. The implements described can be bought for the little money, and drawn by the poor cattle ; and their use will result in better and bigger crops and so in more fodder and hence better cattle. By them the vicious circle can be broken ; and in its place be forged a steady continuous chain of improvement in the lot of the Indian ryot. It only requires the Departments of Agriculture to test them sufficiently to learn their value, and to demonstrate them widely, to ensure the demand that will bring the competitive supply and the low price, and possibly, in addition to a great benefit to the cultivator, also a new industry to India.

I shall be only too pleased to give any further information I can to the departments and the public generally on these implements, and to firms who are interested in the manufacture or marketing of any machinery for the use of the ryot, and I claim to have been at work on this problem now long enough, and under sufficiently varied conditions in Africa and India, to know fairly well what the ryot needs and can utilize, if they will address me at my address at Sepaya (P. O.), District Saran, North Bihar.

GALL FORMATION ON THE ROOTS OF MUSTARD DUE TO A SMUT (*UROCYSTIS CORALLOIDES* ROSTRUP).*

BY

M. MITRA, M.Sc., F.L.S.,

First Assistant to the Imperial Mycologist.

SMUT on mustard roots was observed for the first time in India in 1921 in a small village called Naranpur near Pusa. The mustard crop in a small plot, the area of which was about 100 sq. ft., had an unhealthy growth and formed only a small quantity of seed. On up-rooting the plants it was found that gall-like bodies were adhering to the roots and some of these were as big as 1″-1½″ in diameter and looked like tubers of potato. These galls were found on all parts of the root-system, *i.e.*, on the main root, its branches and even on small rootlets. At first they are small, but gradually increase in size till they attain the dimension mentioned above. The young galls are whitish, while the mature ones are greyish black. When examined, they were found to be enlarged tissues of the roots and full of mycelium in which spore masses were found in abundance. On account of the enlargement, the xylem tissues were found to have undergone degeneration. The infection appeared to be local, as no mycelium was found in the sections of a neighbouring portion of the infected roots.

The specimens were sent to the Director, Imperial Bureau of Mycology, who identified the fungus as *Urocystis coralloides* Rostrup, a very rare fungus reported only twice before on cruciferous plants in Europe. Being apparently unknown elsewhere, nothing is known about its life-history.

Rostrup was the first to find it in Denmark in 1881 on the roots of *Turritis glabra*, a cruciferous plant, and named it *Urocystis coralloides.*[1] Later [2] on in 1899 Lagerhein recorded its presence on the roots of *Matthiola sinuata*, another cruciferous plant, at Palvas in Montpellier, France.[3] He got it only on one plant though he uprooted a very large number of plants. Lastly, the present writer found it in India in 1921 in a village near Pusa on the roots of *Brassica campestris* var. *sarson.*

This fungus is interesting, firstly because it is a very rare fungus, except in a small plot of 100 sq. ft. mentioned above, it has not been found anywhere else round

* Read before the Indian Science Congress, held in Lahore in January 1927.

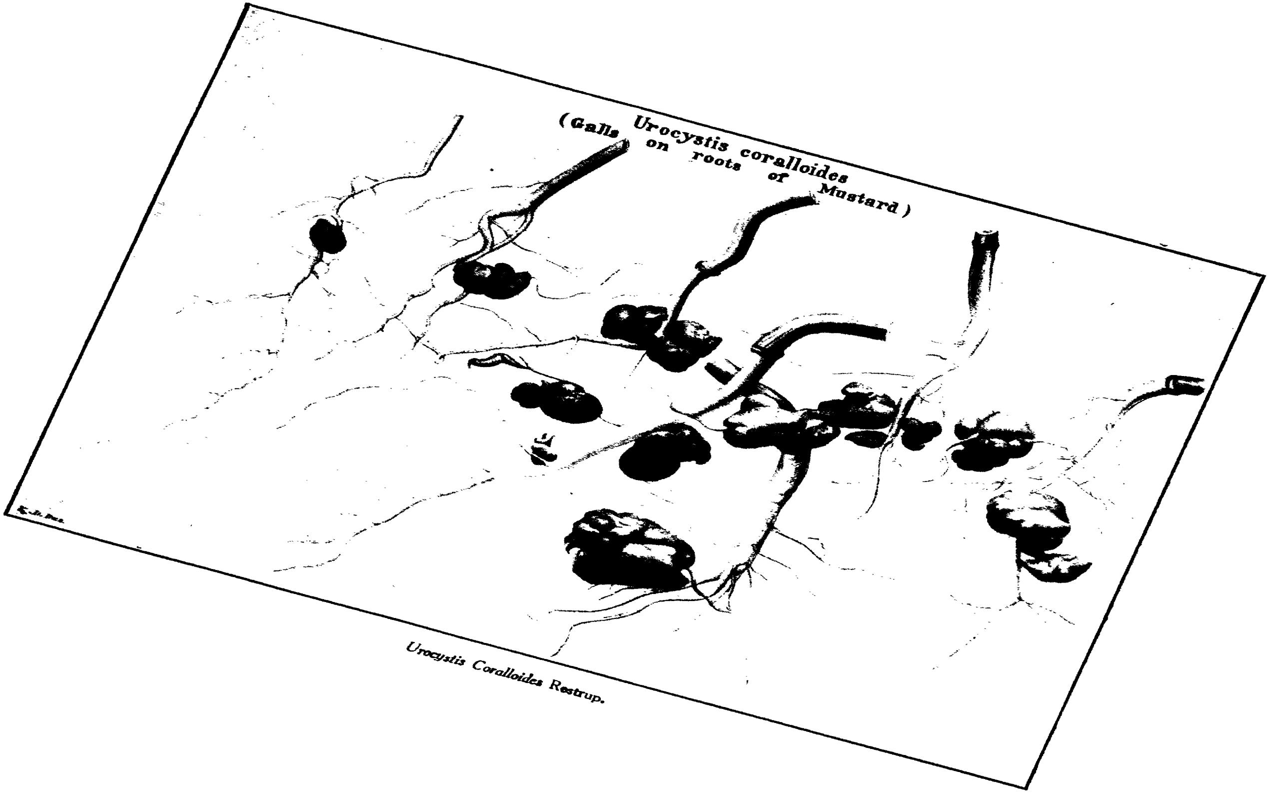
[1] Rostrup, E. Un-nouvel Ustilago souterrain etc. *Revue Mycologique*, Vol. III, No. 11, 1818, p. 32.

[2] Rostrup, E. Wissenschaftliche Original-Mittheilungen. Mycologische Notizen I. Botanisches Centralblatt, Vol. V, No. 4, p. 126, 1881.

[3] Lagerhein, G. Contributions à la Flora, Mycologique des environs de Montpellier, *Bulletin Société Mycologique de France*, Vol. XV, p. 98, 1899.

Galls of *Urocystis Coralloides* Rostrup on Mustard.

PLATE XIII.



Urocystis Coralloides Rostrup.

about Pusa though a good deal of search was made. It is also interesting in view of the fact that very few smuts are found to attack roots and to form such large galls. Since the smut was first noticed, it is found in that particular plot year after year and has not been noticed in any other mustard plot in the vicinity. When the roots decay, spores are liberated in the soil and in due course infect subsequent crops.

In 1923 a quantity of soil was obtained from that plot and put in 15 pots and sown with mustard seeds. All plants in the pots containing infected soil got smutted and produced galls. These pots were kept and in 1924 the previous year's experiment was repeated with the same results. In 1925 the following infection experiment was carried out:—

(*a*) Twenty pots containing infected soil of the previous year were sown with mustard. (*b*) Mustard was also sown in 15 pots after infecting the seeds with the spores of the fungus. (*c*) In 15 pots the soil of which was infected with the spores of the fungus, seeds were sown, and (*d*) 15 pots were kept as a control. All the plants in (*a*), *i.e.*, 20 pots containing infected soil, produced smut galls on the roots, while in the series (*b*) and (*c*) no sign of infection was noticed.

Rostrup[1] described it on the roots of *Turritis glabra* in Denmark as an irregular coral-like, steel grey tumer-like formation. He found it on the roots of numerous *Turritis glabra*, as well as on the branches and small rootlets. The tumour was upto 4 cm. in diameter. The spores consist of 1-3 big, dark brown central cells of 12-16 μ in diameter surrounded by numerous small globular cells of brown colour. The spore ball was 30-40 μ in diameter.[2]

MORPHOLOGY OF THE FUNGUS.

The young galls on the roots of mustard plants are light grey to whitish in colour and later on become darker and are found on roots, rootlets and even on very fine roots. The galls are enlarged portion of the roots, where the rootcells have become enlarged and are full of fungus mycelium and spores. The hyphæ generally run between the cell walls but are also found inside the cells. The hyphæ consist of granular protoplasm, are septate and the cell walls are very thin. Each cell is binucleate. The walls become so gelatinous that they run into each other and blend and are quite indistinguishable from one other. The spores are formed entirely from these gelatinous or mucilaginous hyphæ groups and consist of a group of cells firmly bound together. Spore masses consist of 1-4 fertile cells surrounded by (permanently composed) an enveloping cortex of sterile cells formed from the portion of the hyphæ which envelop the central fertile cells closely at a very early stage.

[1] Rostrup, E. *Loc. cit.*
[2] Rostrup, E. *Loc. cit.*
Saccardo, Sylloge Fungorum, Vol. VII, p. 521.

The central cells are distinguished from others by their large size, dark brown colour and thick coat. The outer cells are lighter in colour. The mycelium in mature galls practically disappears, *i.e.*, is used up in the formation of spore balls and the spore balls lie freely in the tissue of the roots. Fertile cells are 14·3-19·3×11·8—17·2 μ in diameter and the whole ball is 30·1-46·4—21·5—49·6 μ in diameter.

In addition to this species of *Urocystis* on mustard with large tuber-like gall-formations on the roots, there are a few other species known to form gall-like bodies or attack the underground portion of a plant such as *Urocystis Cepulæ* sometime which occurs on bulbs of onions. *U. Violæ* has been found to attack the stem, leaves, petiole and also root-stalk of violets and to form irregular gall-like swellings. *U. gladioli* has been found to attack sometimes corms of cultivated kinds of *Gladiolous*. *U. monotropæ* is found on the roots and stem of *Monotropi* in Belgium and *U. Orobanches* has been recorded on the roots of Orobanches in Europe.

In order to study the mode of infection and the life-history of the smut on mustard several attempts were made to germinate the spores, but unfortunately none succeeded. The fungus when present in the soil, as seen in the infected soil, can infect the plant, but the factors under which the spores germinate had not been found under laboratory conditions.

MICRO-ORGANISMS AND THE PRODUCTION OF *DAHI*.

BY

C. S. RAM AYYAR, B.A.,

First Assistant to the Imperial Agricultural Bacteriologist (Industrial).

Dahi (Sanskrit, *Dadhi*), or milk curdled by the growth of certain lactic acid forming bacteria, is a preparation known in India from the earliest times. It is mentioned as an article required in the Vedic rites and ancient medical books speak of its therapeutic value. It is a common article of diet amongst Indians, and is generally taken either mixed with rice or with salt or sugar.

It is prepared by heating milk to boiling, allowing it to cool to blood heat and adding a small quantity of *dahi* from an earlier batch. The milk is covered and kept overnight; by the next morning it curdles, producing a smooth homogeneous curd with an acid taste.

Owing to the high temperature in the plains, especially in summer, it is difficult to keep milk sweet there for more than a few hours. Milk being a favourable medium for bacterial growth, putrefactive organisms multiply in it rapidly and in a few hours change it into a foul-smelling liquid. The heating of the milk to boiling point destroys most of the unwanted germs, and the subsequent introduction of the *dahi* from a previous day's preparation serves the purpose of inoculation with certain organisms which, by producing acid, curdle the milk, and the acid produced checks the growth of gas-forming and putrefactive bacteria which would otherwise spoil the curd. Thus, by this treatment, the milk can be kept for a longer time in a state fit for human consumption.

The use of *dahi* during meals, which is very common in Southern India, results in the daily renewal of the lactic acid bacteria in the intestines and these, according to Metchinikoff, by virtue of the acid produced, oust all the putrefying organisms from the alimentary tract and prevent premature decay.

For butter making, milk is curdled by inoculating with *dahi*, which, after churning with a little water is known as *mattha* or buttermilk. Butter could be separated from the *mattha* if churned for a sufficiently long time. This buttermilk, with or without removal of butter, is used as a pleasant and refreshing drink, especially in summer. Ayurvedic physicians recommend *mattha* to invalids and persons of weak digestion as being more easily digestible than raw milk.

Very little work has been done in India regarding the micro-organisms found in Indian *dahi*, although literature abounds in references to work carried out on similar preparations in other countries. Such fermented milk preparations are

known by various names as Yoghourt in Bulgaria, Mazun in Armenia, Leben in Syria and Egypt, Koumis in Russia and Kefir in the Caucasus regions. In most of these products, the lactose or milk sugar is changed partly into lactic acid by lactic bacteria and partly into alcohol by yeasts. In Koumis, for example, the fermentation produces one per cent. alcohol and 0·75 per cent. of acid, whereas in Yoghourt the action of yeasts is held in check by the rapid development of lactic acid bacteria. *Dahi* differs from these products in containing no alcohol.

Bacteriological studies of the above-mentioned preparations have shown that they contain one or more yeasts living symbiotically with lactic acid organisms, rods or cocci.

Smears made from *dahi* show rods, some very long, cocci, short rods joined in pairs, and yeast cells (Fig. 1). The long rods when stained with watery methylene blue are seen to contain granules which are stained pink. As early as 1909, Chatterjee[1] described this lactic acid forming organism in *dahi* and named it *Streptothrix Dadhi*. We have examined *dahi* made at various places in India in different seasons and have found in *dahi* prepared in the hot weather the same organism as the one described by Chatterjee. It belongs to the B. *Caucasicus* or *Kornchenbacilli* group described by previous investigators in Europe.

The chief characteristics of the organisms of this group are—(1) the unusual length they attain in milk and whey, especially in old cultures, (2) the formation of granules in young cultures in milk differentially stained with watery methylene blue and iodine, (3) the lack of growth on ordinary culture media like beef peptone agar, gelatine or potato, (4) their high optimum temperature for growth, *viz.*, between 98°—108°F., and (5) the high degree of acidity produced in milk.

In summer, *dahi*, 24 hours after inoculation, contains this organism almost exclusively, generally in the form of rods 4 to 8μ.[2] long and 1μ. broad (Fig. 2). Long threads, up to 50μ in length, are sometimes met with in cultures kept at low temperatures. In pure cultures, these organisms produce 1 to 1·4 per cent. acid calculated as lactic acid in milk kept at 98°F. for 24 hours, and the acidity increases to 2·2 per cent. in 7 days when, probably owing to the high acidity and accumulation of metabolic products, the organisms die. The optimum temperature for their growth is 98°F.; they are inactive at 108°F. and at 68°F.; they are killed by being heated to 150°F. for fifteen minutes. They grow best in the absence of air, and curdle milk into a smooth firm curd, free from gas bubbles and with only slight extrusion of whey.

Dahi prepared in winter, unlike that in summer, is less acidic in taste. This is due to the fact that the chief agent then resposible for curdling is a short rod

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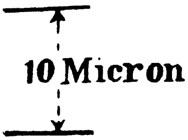
[1] Chatterjee, G. C. A new lactic acid producing streptothrix found in the fermented milk of India called *Dadhi*. *Centralblatt* Bd. 1, Vol. LIII, p. 103, 1909.

[2] Micron $\mu = \dfrac{1}{25,000}$ inch.



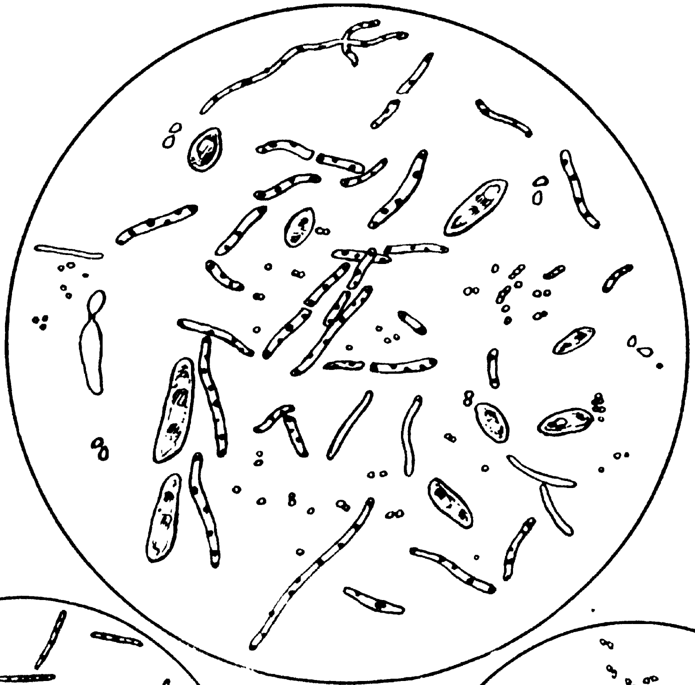


Fig. 1.

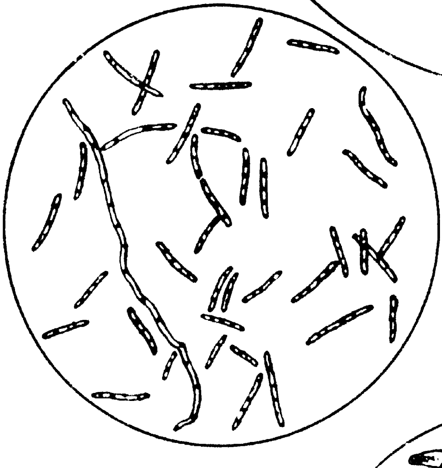


Fig. 2.

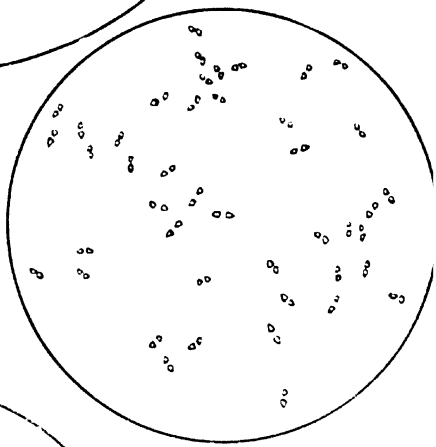


Fig. 3.

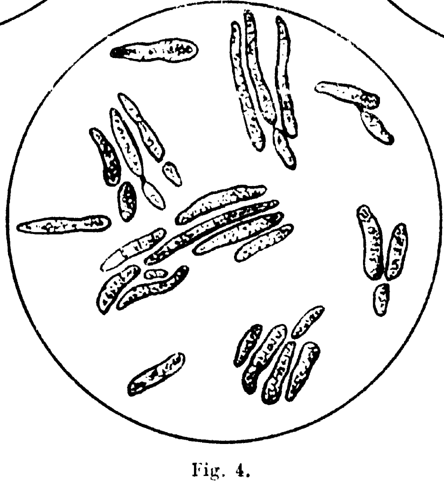


Fig. 4.

0·7μ. in length, occurring in pairs (Fig. 3). This organism grows well at 68°F. and produces about 0·5 to 0·7 per cent. acid in 24 hours. This class of organism is normally present in the air of dairies and is similar to the lactic acid organism found in starters used for butter and cheese making. The maximum acidity produced by this organism is only one per cent. In winter, when the temperature is not favourable for the growth of the *Streptothrix*, this small germ gains the upper hand and " sweet *dahi* " results. If, however, the milk is kept in a warm place, the usual *Streptothrix* appears with its characteristic high acid production, showing that the *Streptothrix* is always present in the *dahi* in a dormant state, ready to start growing when the temperature becomes favourable. The acidity produced by this short rod is not sufficient to check the growth of extraneous organisms ; hence the *dahi* made by the action of this organism will not keep so well as that made by the action of the *Streptothrix*. Occasionally, in winter, we find also a spherical organism or coccus. This, like the short rod, grows at low temperatures and does not produce much acid.

Examinations of samples of sterilized milk from Karnal that had curdled while being stored in the dairy, in consequence of contamination from the air through leaks in the container, gave the interesting result that, in the case of samples that curdled in the cold weather, the cause of curdling appeared to be a short rod producing a curd of low acidity, similar to the organism found in *dahi* prepared in the cold weather, while in the samples that curdled in the hot weather, the long *Streptothrix* organism was found and the curd tasted strongly acid.

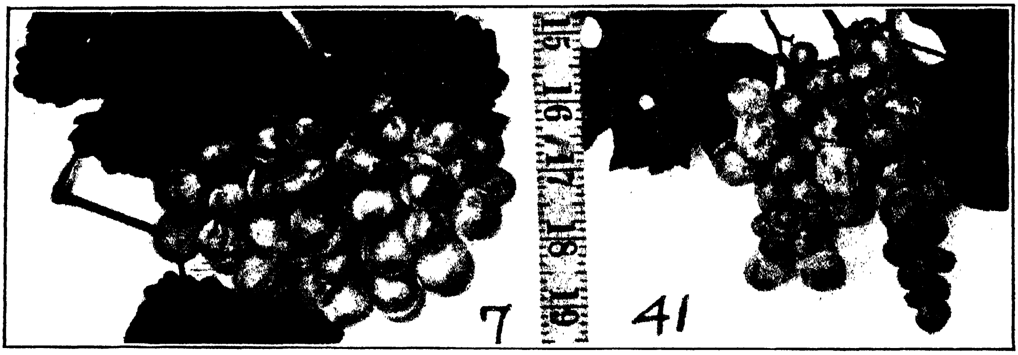
Always associated with both types of lactic acid organisms in *dahi* is a yeast of the Torula type (Fig. 4), which does not form spores. The cells are elongated and are 4 to 7μ long and 1·5 to 3μ broad. The yeast does not grow in fresh milk but only when the milk is curdled and has an acid reaction. It needs a plentiful supply of air and therefore grows only on the surface of the curd. As it consumes the lactic acid formed by the other organisms we find that the acidity of the *dahi*, after reaching a certain maximum, decreases when the yeast begins to grow.

As mentioned above, the *Streptothrix* in pure culture is killed by the acidity and the accumulation of bye-products after 7 days at 98°F. When, however, it is grown in association with this yeast it was found to remain alive for a month. In the case of the short rod, which in pure cultures in milk dies in two weeks at 86°F., inoculation with this yeast has been found to keep the culture alive for over four months. It may be that some of the bye-products of the yeast (vitamins ?) contribute to the lengthening of the life of the lactic acid organisms. At all events. the lactic acid organisms in conjunction with this yeast can thrive for a much longer time in *dahi* than they can alone, and therefore their cultures with yeast are easily maintained alive and active..

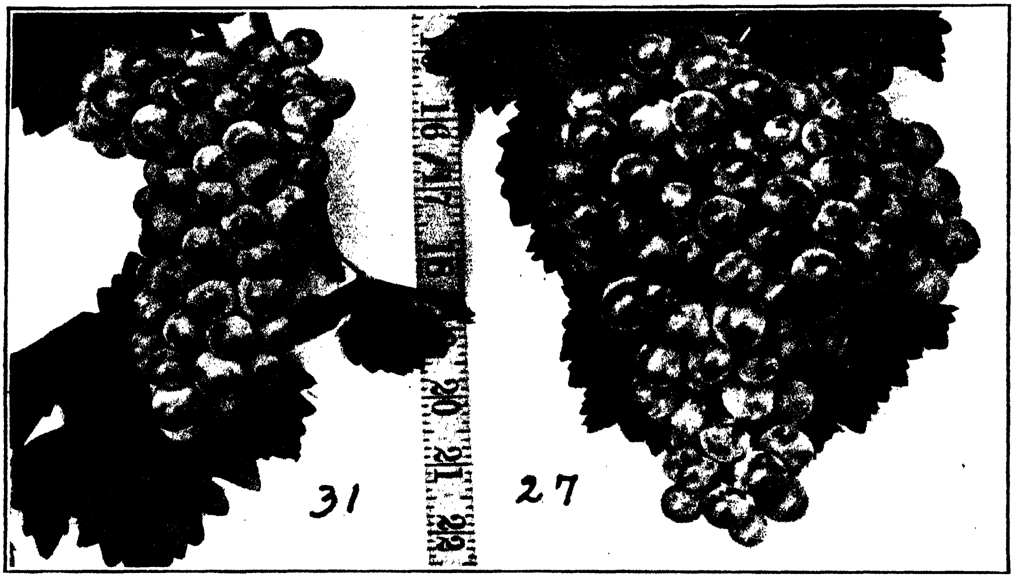
The yeast grows well in media containing cane sugar or glucose but does not produce alcohol from any of the sugars. It produces a characteristic wrinkled

appearance on old cultures of *dahi*, imparts to it a peculiar flavour, and peptonises the curd slowly.

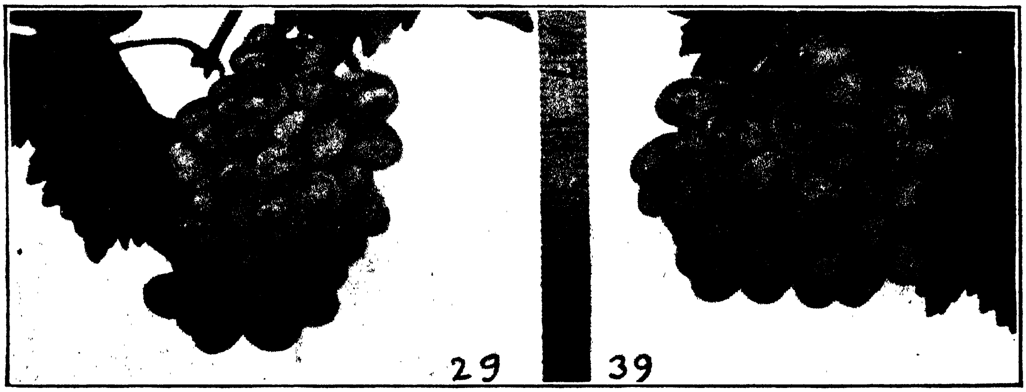
We have also carried out certain experiments to see whether cultures of lactic acid bacteria from sources other than *dahi* could be kept alive in agar for a longer time in mixed cultures of the organism and yeast than they do when grown alone, and in all cases it was found that association with yeast gives the organism a longer lease of life.



No. 41 has developed seedless berries like Pandhari Sahebi.



Note the compact nature of No. 31 bunch.



Note the elongated nature of berries.

IMPROVEMENT OF PANDHARI SAHEBI GRAPE BY THE USE OF SEEDLINGS.

BY

G. S. CHEEMA, D. Sc.,

Horticulturist to the Government of Bombay.

The cultivation of grapes is perhaps the best developed fruit industry in the Presidency of Bombay. There are about 1,000 acres under grape cultivation in the neighbourhood of Nasik and they are chiefly of the Bhokari type and of rather low quality. Owing to the cultivation of this inferior grape, which has only a limited market, the extension of the grape growing industry has not been so rapid as would otherwise have been the case. This Bhokari grape contains a small percentage of sugar, and is, therefore, more or less insipid in taste. However, it fetches a higher price than might have been expected, owing to the fact that it is the only grape available in the market at that time. The season extends from February till April, while the Quetta grapes or foreign varieties, such as the Spanish or Italian grapes, arrive later. It is, therefore, sold in the market in Bombay at an average of four to eight annas per pound.

The improvement in the quality of the grapes grown in the Deccan is, therefore, a matter of great importance, and a good deal of time and study has been devoted to it. This work has necessitated a thorough study of all the types which are grown in the Bombay Presidency. It was early noticed that a variety known as Pandhari Sahebi is the best grape now in cultivation, for table use, but it is partially self-sterile, a characteristic already dealt with in an article in "*The Agricultural Journal of India*" in November 1924. It was found, in fact, this variety requires pollination with Bhokari or any other fertile type in order to bear fruit, and that this necessity, together with its shy bearing habit, prevents its cultivation on a large scale. Consequently, the improvement of the Pandhari Sahebi variety by breeding and selection was undertaken with the idea of developing a type which would bear profusely without losing the quality of the fruit of the existing variety. The chief characteristics of the existing Pandhari Sahebi variety are :—

(1) Vigorous growth habit with leaves not much lobed, rough to the touch, with serrate-crenate margins, petiole slightly pale pink.

(2) Distinctive and very agreeable flavour of the berry.

(3) Fairly large berries with a shining transparent appearance, and the best qualities of a table grape.

(4) Flowers mainly hermaphrodite, functioning as female owing to completely or partially abortive pollen.
(5) Uniform ripening and close set berries if properly fertilized.
(6) A somewhat late, but long, blooming season.
(7) A capacity to dry well as raisins, when necessary.

Thus it will be seen that the strain has all the good qualities of a table grape. The only objection to it is that it lacks in (1) productiveness and (2) self-fertility. If its productiveness can be increased, and if it can be made self-fertile, it will be one of the finest grapes in India.

Previous Investigations.

It may be mentioned here that improvement of grapes by raising seedlings is not a new thing. Hedrick[1] states that a large number of types were evolved by raising seedlings. Patane[2] mentions that a crop of American-French vines was raised from seeds in Italy in order to select better types for cultivation. Munson[3] explains in an elaborate manner how he raised his seeds and how he grew them into bearing vines for his studies. In fact, it is a common practice with nurserymen to grow vines from seeds and then select the better types for use. But so far vines selected in America, France or any other country have not given satisfaction when cultivated in the Deccan. It would seem wise, therefore, that attempts should be made to produce desirable types out of our indigenous vines. It was with this aim in view that the hybridization of Bhokari with another variety known as Neelum was undertaken in the Ganeshkhind Botanical Gardens, Kirkee, by Dr. W. Burns in 1920. Only one seedling of this collection, however, at present survives, but it has not yet fruited.

In the years since 1921, a further attempt has been made to see how far new types, with the desirable characters of Pandhari Sahebi, but with greater productiveness and greater self-fertility, could be produced by using seedlings obtained from grapes of this variety. The results are already of some interest.

Before describing the types obtained by this method, it may be noted that the self sterility of the Pandhari Sahebi variety seems, in part, at least to be due to the climatic conditions of the Deccan. When transferred to some parts of the Punjab and Sind it is far more self-fertile than in the Deccan. It has, for instance, given attractive and uniform bunches when grown at Montgomery (Punjab) where further trials are being made, and is being grown for trials in Sind. In the Deccan, however, it only gives good and uniform fruit when it is grown side by side with other types.

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[1] Hedrick, U. P., and Anthony, R. D. Inheritance of certain characters of grapes. *Journal Agricultural Research*, Vol. IV (1915), page 315.

[2] Patane, G. The selection and hybridization of American vines in Italy. *Inter. Review of Science and Pract. Agri.*, VII, No. 10 (1916).

[3] Munson, T. V. Foundations of American grape culture. New York, U. S. A., 1909.

In the present experiments, a large number of seeds were collected from well formed fruits of the Pandhari Sahebi variety in March 1922. These were sown in pots, and germinated in two weeks. Selected seedlings were planted out, at $2\frac{1}{2}$ months old, in the field, and by this means 64 seedlings were obtained, which were allowed to grow without further nursing, being treated exactly as other plants raised from cuttings. The land was, purposely, selected as being poor and shallow, to bring into prominence the yield characters, and so make the final selection easy. Several seedlings (six in number) bore fruit in 1925, and in 1927 fruit was obtained from fifteen of them.

The following is a detailed description of the various types of plant and fruit obtained in these fifteen types which have already fruited.

No. 3. Growth vigorous, self-fertile, compact bunch, medium berry, small seeds, soft.

No. 4. Growth poor, partially self-fertile, loose bunch, small and medium sized berries.

No. 5. Fairly good growth, loose bunch, berry oval, medium in size, partially self-sterile.

No. 7. Growth vigorous, loose bunch, big elongate berry, with 2 to 3 seeds, skin tough, self-fertile.

No. 9. Growth good, partially self-sterile, loose irregular bunch, medium berry, 1 to 2 seeds.

No. 11. Growth poor, partially self-sterile, loose bunch, berry ovoid, medium in size.

No. 16. Growth vigorous, bunch loose, bloom late, berry small, oval and oblique, partially self-sterile.

No. 18. Bunch loose and small, berry medium, fertile, makes good raisins.

No. 21. Bunch compact, berry large, reddish, sweet, leaf like Pandhari Sahebi.

No. 24. Growth meagre, sterility very great, berries medium size, globular, 1-2 seeded, makes good raisins.

No. 26. Compact small bunch, berries small, fertile.

No. 27. Growth fairly vigorous, slight sterility, slightly loose bunch, berries medium, 2-4 seeded, tough skin, quality not very good.

No. 28. Small bunch, inferior.

No. 29. Growth vigorous, partially sterile, elongated but compact bunches, berry very much elongated, seed generally one.

No. 30. Good growth, bunch long and compact, partially self-sterile, berries elongated.

No. 31. Best growth, sterile, bunch compact and thickly packed up, berry medium, 1-4 seeds.

No. 35. Poor growth, long loose bunch, berries much elongated, of medium size, seeds few.

No. 38. Partially self-sterile, compact bunch, berry small and elongated, seeds 1-2 in number and soft, skin soft.

No. 39. Partially self-sterile, bunch loose, berry elongated, seeds soft, skin soft.

No. 41. Fair growth, self-sterile, loose bunch, seeds few.

No. 94. Fertile, compact bunches, berry small, skin tough, bunches medium size.

It can be seen from the above description that no two seedlings gave entirely similar fruit. A large number of seedlings, as would be expected, bear inferior fruit. As regards blossom, these seedlings fall into the following main groups :—

(1) Self-sterile, such as number 41.
(2) Partially self-sterile, such as Nos. 4, 9, 11.
(3) Self-fertile, such as Nos. 3, 7.

Apart from this, the shape of the bunches present an interesting study. Nos. 31 and 33 have compact bunches, while Nos. 3, 39 and 41 have loose bunches.

The most interesting feature, however, is the study of the quality of the berry. Number 29 has berries which resemble true Pandhari Sahebi. No. 21 has got big berries with a blackish colour. No. 27 presents berries which resemble Bhokari. Nos. 35 and 29 have developed elongated berries with very few and soft seeds.

A very careful study of the growth, disease resistance as well as mildew resistance is being made. These results will be given separately after the final selection of the seedlings has been made.

THE REINFORCEMENT OF ORGANIC MANURES WITH ARTIFICIAL FERTILISERS.

BY

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THE great and preponderating value of humus in Indian soils, recognised by every agriculturist from the practical cultivator to the scientific experts of the Agricultural Department, has created a permanent and entirely justifiable bias or prejudice in favour of the use of organic rather than of artificial manures. No exponent of the value or convenience of the latter, if he knows his business, will suggest complete substitution of organic manures by artificials, but will invariably recommend combination of the two classes in such a way as to implement one another. It is a well recognized fact in Indian agricultural practice that supplies of such organic manures as cowdung and oilcakes fall far short of the requirements of the arable areas as a whole ; this defective supply generally leads to concentration of the available quantity upon that part of the cultivator's holding which will show the best return from the application, and upon this fraction the revenue crop which is to give him a harvest convertible into cash is raised. This policy of concentrating available manures upon the best bit of land leads inevitably to an increase in the original discrepancy between the good and the bad areas, to a falling off not only in the quantity but in the quality of the cultivator's food crops, and in some cases to the adoption of unsound rotations in the endeavour to secure a higher percentage of revenue crops in the latter. All these disadvantages arise largely from the insufficiency of the supply of organic manure to cover the total arable area of any district.

Now this insufficiency is mainly determined by the rate per acre at which the cultivator finds it necessary or advantageous to apply his cowdung or oilcake so as to get an adequate return in the form of increase in crop for the cash expenditure, or its equivalent, involved. This rate per acre is largely determined in actual fact by the stimulating effect on the crop of the nitrogen content of the manure, as, although the average ryot is aware of the value of organic fertilizers as improvers of the condition of soil, he has a much more vivid conception of their action as crop stimulants and regulates the rate of application accordingly. Recent field experiments designed with a view to obtaining reliable information on this subject have been carried out by the Agricultural Department in Bengal and, unlike most manurial experiments in this country, have thrown much light upon the subject. Thus

it has been shown that in a case where the usual local rate of application of cowdung was 200 Mds. per acre, the use of a nitrogenous fertilizer, in this case Sulphate of Ammonia, in place of part of this amount, resulted in an increase of crop not only sufficient to pay for the higher cost of the artificial fertilizer, but to give a substantial increase in profit for the mixed application, as compared with the control on which 200 Mds. of cowdung was used alone. To put it more clearly, in one case cowdung at the rate of 200 Mds. per acre was used and in the other 150 Mds. of cowdung together with $\frac{3}{4}$ Md. Sulphate of Ammonia; the latter combination although actually supplying no more nitrogen, gave an economic return showing a decided profit as compared with the cowdung alone. Incidentally, the available condition of the Sulphate of Ammonia nitrogen would enable the latter to secure an immediate increase as compared with a delayed one from the cowdung alone.

Here then we have a valuable indication of a direction of advance in agricultural practice which should lead to advantages of a serious order. Firstly, it appears that the use of artificial nitrogen because of its present low price and the ease of control of its action is attended with direct economic advantages in the form of early and profitable returns. Second, and still more important, is the fact that by dilution or reinforcement of the available supply of organic manure with artificial fertilizers this supply can be made to cover a greater area of land. Should further experiment confirm this observation and extend the operation of this method to other crops and soils, we should have arrived at a method whose importance can scarcely be exaggerated. In order to obtain any adequate comprehension of this subject it is necessary to realize that, whilst organic matter as such is necessary to give to an arable soil certain physical characteristics essential for fertility, organic manures, which should properly be considered as valuable mainly on account of their contributing to the supply of this soil constituent, are in most cases actually relied upon to provide nitrogen for the crop. Now the amount of this element contained in such manures as cowdung is small and in order to bring it into an "available," *i.e.*, usable, condition much time and labour is required; the ploughing and harrowing or cultivation necessary to produce this result incidentally destroys a large proportion of the organic matter in the soil, so that in order to obtain relatively small amounts of nitrogenous plant food large quantities of valuable organic matter are sacrificed, thus reducing the mechanical texture or "tilth" of the soil below its proper level and making it necessary to replace this loss if fertility is to be maintained. This is obviously a wasteful method and it is the more or less unconscious recognition of this fact which has been partly responsible for the adoption of the unsound practice above referred to of concentration of the available supplies of manure upon those portions of the arable area carrying the revenue or cash crops. Frequent references are made in public prints, and in more important pronouncements, to the necessity for raising the, at present, low level of fertility of Indian soils, especially with reference to the production of food crops. It does not seem to be sufficiently realized that in India there is a general distinc-

tion between revenue or cash crops and food crops. Such crops as Tobacco, Sugarcane and Jute, are specially prized as bringing in actual cash returns to the grower, of a much higher order than those obtainable from the saleable surplus of such food crops as rice, wheat and maize. The extent to which the former class will displace the latter in the cultivator's fields will depend of course upon several considerations, such as the proportion of suitable soil and the necessities of rotation, but the fact remains that there is a strong tendency not only to reserve the better soils for revenue crops but to concentrate such supplies of manure as are available upon these portions of his land at the expense of the areas of lower fertility and of the food crops grown thereon. The ultimate result of this policy is to exaggerate the original differences in fertility between these two classes of land and by so doing to risk the ultimate extinction of large areas of food-producing soils as a consequence of gradual exhaustion of their fertility. If any alteration is to be made in this practice, it will probably depend upon diversion of part of the supply of organic manures from the revenue crop soils to the, at present, relatively poorer food crop areas, and the introduction of the method of diluting and extenuating such supplies by the use of artificial fertilizers appears to offer a means of doing this with chances of economic success. It is therefore worthy of consideration whether the experimental work on fertilizers, which has lately received a new lease of life as a consequence of somewhat tardy recognition of its importance, should not include a special set of experiments to determine how far it is possible to extend the area under treatment with indigenous organic manures by dilution of the latter with artificial fertilizers.

Numerous experiments dealing with mixtures of indigenous organic manures and artificials have indeed been carried out at various times and in various places in India, but there is no clear indication that the intention of these trials was to discover how far the inadequate supplies of the former class of manure could be extended by the complementary use of the latter. It is suggested therefore that it would be well worth while not only to examine old records, both published and unpublished, with a view to obtaining information on this point, but to institute fresh experiments for a similar purpose. The recent drop in the prices of artificials should form an additional inducement to explore this possible method of developing the agricultural potentialities of the country.

SELECTED ARTICLES

THE RAISING OF SEEDLING CANES IN JAVA, II.*

(Concluded from Vol. XXIII, Pt. I.)

II. Lines of Work and Technique.

EARLIEST CROSSING WORK.

DURING the campaign against *serch*, trials were first made with various kinds of cane grown on the other islands of the Archipelago, but these proved to be either of too low yield or only partially resistant. Therefore crossing was commenced. Numbers were given to the seedlings selected, and a record was kept of them ; and in 1897 these were marked by the added letters POJ (Proefstation Oost Java), and those obtained from 1903 onwards were included. In Table V, extending over 11 pages, BANNIER gives the numbers and origin of all such seedlings as have been used in crossing work or were otherwise distinguished. Later, this series became official for Java as a whole, and seedlings raised in other parts were added. In a separate column the seedlings still retained in the collection are indicated. From a careful study of this Table, a great deal of information can be obtained as to the direction, from time to time, of the line of work. Work done, previous to 1893, in raising cane seedlings was described in the *Archief* by KOBUS in 1893, and this is not dealt with by BANNIER.

In 1893, WAKKER, the Director, was in charge of the seedling work. Free crossing was the rule, therefore the seedlings were either selfed or wind-fertilized. Certain definite crossings were however attempted, but did not lead to any permanent results : it is interesting, however, to note that Black Cheribon was crossed with Kassoer in that year. Among the wind-fertilized seedlings, one of considerable value was, however, met with, namely 100 POJ. Years after, it became possible to suggest the parentage of this variety, and JESWIET and BREMER, in 1916, published papers making it practically certain that 100 POJ arose from an accidental pollination of Bangjarmasin hitam by Loethers (a cane obtained from Mauritius by WAKKER, according to EARLE). From 1894 to 1896, free crossing continued and nothing important accrued, but, besides 100, 116 and 125 retained these numbers in the new POJ series. It was recognized that the chance of the best father meeting with the best mother was extremely remote by free wind-fertilization.

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* Reprinted from *Int. Sugar Jour.*, XXIX, No. 337, Feb. 1927.
The parentage of certain POJ kinds, and of the best known other Java seedlings.

Ennobling of Chunnee.

In 1897 Kobus struck out a new line. It will be remembered that he visited North India for the collection of new types of sugarcane, on the chance of their being resistant to *sereh* ; and brought over some 18 varieties, which he grew on the island of Banca, as a quarantine station. Of these, he considered Ruckree and Chunnee to be the best, and transferred the latter to Pasoeroean in 1896. This cane was described as very thin and not long, extremely hard but with a good yield of sugar, very freely tillering and with high resistance to *sereh.* Botanically, Bannier states that these Indian canes have recently been described by Jeswiet, and given the position of a separate species, under the name *Saccharum Barberi*, to distinguish them from the ordinary tropical kinds known as *Saccharum officinarum.* Kobus began at once to cross Chunnee with tropical canes. The latter are termed " noble " in the paper, and seedlings obtained by crossing them with Chunnee are appropriately called " ennobled Chunnee." When the latter are again crossed with tropical canes, they are termed " twice ennobled Chunnee," and so on.

In this year, 1897, Kobus crossed Chunnee with Striped Preanger, and subsequently with Black Cheribon. On the whole, however, the former is now known as the better cross, in that it has the power to hand down better characters than Black Cheribon. This *direct crossing* of Chunnee with tropical canes continued till about 1912, and Bannier therefore describes this as the " Chunnee Period."

In 1898 and 1899 Chunnee was crossed exclusively with Black Cheribon, but later, others were also used : this period of direct crossing lasting until 1905. The following additions to the POJ series were the result : 33, 36, 139 (1897), 213, 228 (1899), 826, 979 (1905). The full parentage of these and other of the more important POJ seedlings is given in the genealogical diagram on Table VII, which is reproduced in the present paper. The chief characters of these direct Chunnee seedlings are as follows : thin, moderate yield of sugar, definite hollow centre in the canes, resistant to *sereh*, strong root system and therefore very hardy, great tendency towards logging, and very high susceptibility to mosaic (strepenziekte).

In 1905, the best direct Chunnee seedlings were crossed with one another, and the resulting seedlings are known as *derived Chunnee* descendants (afgeleide Chunnee nakomelingen). The best results were obtained in 1907, by crossing 213 POJ by 369 POJ and 385 POJ by 181 POJ, and the following were produced : 1499, 1507 and 1547 POJ. These were distinguished by having a better habit than the direct Chunnee seedlings, their sugar production was very good, there was less lodging (except in 1507), they were smaller, had a satisfactory to high weight of cane, but retained the susceptibility to mosaic. Because of this defect, and also the fact that, during the year in which they were distributed, better tropical canes were available, the derived seedlings exercised a less permanent effect on the industry than the former direct ones. Although they replaced the latter, and were more widely spread, they themselves were more quickly discarded.

Further ennobling of Chunnee has also been attempted, and among others the twice ennobled 2806 POJ was obtained by crossing 1547 POJ with 247B. This seedling gives good production of sugar on good land, but rarely better than tropical canes. Thus, the ennobling of Chunnee has led to no permanent improvement in the canes of Java. After 1914, crossing with it rapidly declined, and at present Chunnee is never used, and its seedlings rarely and then only in combination with Kassoer blood. From this latter combination 2753 POJ was obtained, a form which unites the good characters of both ancestors, with the exception of the Chunnee susceptibility to mosaic. This seedling gives great returns on heavy, wet, clayey soil.

BREEDING WITH TROPICAL CANES ALONE.

Before 1910, a number of crossings were made between tropical canes, but with little result ; and very few seedlings were added to the POJ collection. The Chunnee work was at this time considered to be more important, and still took by far the leading part in the yearly campaigns. Again, after the cessation of the latter, about 1912, and before Kassoer had attracted attention, for several years a great deal of work was done with tropical canes. The most various parents were used : Bandjarmasin hitam, Black Cheribon, Green German New Guinea, Batjan, Loethers, and many others. And, further from 1913 to 1916, much selfing was tried among them.

Certain seedlings of good habit were produced, especially with Fiji and Green German New Guinea, but the production of sugar was low in most, and all of the better ones were far too susceptible to *sereh* and mosaic. Thus no permanent improvement was effected. Since resistance to disease still remained the chief desideratum, in later years crossing among tropical canes was carried on, rather for the furtherance of studies in the inheritance of characters in the sugarcane, than for the production of useful commercial varieties.

THE ENNOBLING OF KASSOER.

This cane has given better results than Chunnee. Far long the nature of Kassoer was uncertain, and at first it was regarded as a distinct kind, strong in its growth and resistant to disease. For this reason, as has already been noted, it was crossed with a tropical cane in 1893 ; and this was repeated in 1907, 1908 and 1909. But the low percentage of sugar in the seedlings, even when crossed with rich canes, led to its being discarded. In the latter three years, Glagah (*Saccharum spontaneum*) was also thus crossed, but the results were unsatisfactory. In 1911, Kassoer was, however, again tried by WILBRINK, when it was crossed with both Black Cheribon and 100 POJ. Out of the great number of seedlings obtained, some 200 were added to the POJ collection. These were as before strong in rooting and growth, and resistant to *sereh* and mosaic, but all of them had little sugar.

About 1915, JESWIET was able to throw fresh light upon the nature of Kassoer, and the causes of its previous failures to satisfy. This was the result of a careful study of the morphological characters of *Saccharum spontaneum*, *Saccharum officinarum* and Kassoer; and he came to the conclusion that Kassoer was probably the result of a chance hybridization between these two species. And this assumption was strengthened in 1917 by crossing Glagah direct with a seedling of Black Cheribon × Fiji; the resulting seedlings, 2772, 2775, and 2776 POJ, were in all their characters very similar to Kassoer and could indeed safely be described as "self-made Kassoers" (eingemaskte Kassoers). BREMER, in 1922, added confirmation, by a study of the numbers of chromosomes in the two supposed parents and in Kassoer itself. Kassoer can thus be regarded as an ennobled Glagah or *Saccharum spontaneum*. The latter has little juice and nearly no sugar, Kassoer has sugar and distinctly more sap. Crosses between Kassoer and tropical canes (twice ennobled Glagah) have better appearance and higher sugar, coupled with strong root growth and resistance to disease.

When the true nature of Kassoer had been determined, an impetus was given to its further ennobling, and this took the place of the crossing between tropical canes in the annual programme. In 1916, various Kassoer seedlings obtained by WILBRINK in 1911 were crossed with EK 28, but the results were not a great success. In 1917, however, attention was attracted to another of these seedlings, 2364 POJ (100 POJ × K). It had very good habit, was erect, sufficiently thick and very long jointed, had robust growth, a strong root system and a good leafy crown, and its sugar content was better than that of its congeners. But its most important character was its capacity for handing down its good qualities to its offspring, which is frequently not the case with good cane varieties. Of many other seedlings of this series, tried in 1917, 2364 POJ has proved to be easily the best.

It was crossed with 2571 POJ, 2592 POJ, EK 28 and Batjan, and a number of its seedlings were added to the POJ collection in 1918 to 1919. Crossed, as mother, with EK 28, it gave among others 2714, 2722 and 2725 POJ; and with Batjan, 2727 POJ. These twice ennobled Kassoer (thrice ennobled Glagah) have the robust growth, strong root system, and complete or partial resistance of Glagah, with sufficient sugar and the good habit of the tropical fathers, grand and great-grand parents. The sugar content of some was very good. Their productivity, especially in good light soil, was not very high, and they required much water. On clayey soils, especially such as were not of the best quality, 2727 POJ became prominent, while 2722 and 2725 required much water and early planting. The POJ collection thus reached a higher level with Kassoer than with Chunnee, and after 1924 the area planted with POJ seedlings distinctly increased.

From 1917 onwards the same line of work was continued. Many variants were tested in the crossing, but 2364 POJ × EK 28 consistently gave the best results. From this cross arose, in 1921, the seedlings 2878 and 2883 POJ, which surpassed the 1917 three (2714, 2722 and 2725 POJ). The best of the latter plants flowers very

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freely and consequently soon become pithy, whereas 2878 POJ flowers very little, which is a great advantage, has high sugar and great weight of cane, and is very slightly affected by mosaic. POJ 2883 gives somewhat less sugar, flowers more and is very susceptible to mosaic. Every year hundreds of seedlings are raised, in the hope of obtaining better ones. New possibilities may arise, chiefly by way of other tropical parents, with as high sugar as possible, and especially the power to pass on their characters. The increase in resistance is not now of so much importance, as this is thought to be fully guarded by Kassoer.

Apart from this work with 2364 POJ, many other seedlings of the same parentage have been tried, as well as Glagah itself with the idea of obtaining a better basal cane than Kassoer. A certain amount of thrice ennobling of Kassoer (four times ennobling Glagah) has also been attempted, and for this work the best mothers appear to be 2722 and 2875 POJ. The percentages, in the batches of seedlings, with good sugar was higher, but the average resistance less. Hence the resistance to disease occupies an important position, again, in the selection of these seedlings with attenuated Kassoer blood. Lastly, besides tropical canes with high sugar content and low resistance, Kassoer seedlings are being crossed with such kinds as Green German New Guinea, Fiji, Sampang A and Sawoe Kroepoek, forms which have greater resistance to disease and very good habit, but are comparatively low in sugar. As might be expected, in the batches of seedlings obtained, higher resistance is met with, but the sugar content is low; and the chance of obtaining the desired forms is accordingly less, although the method is considered worthy of further trial.

ENNOBLING SACCHARUM SINENSE.

During recent years, a good deal of crossing has been done with this class of canes, which are extensively grown in China, Formosa, British India, and in many other places. The best known are Tek-cha, Puri, Uba, Zwinga, Kavangire and Cayana. The main characteristics of these canes are: low weights of cane, reasonably good sugar, strong root system, and resistance to *sereh*: their susceptibility to mosaic varies in the forms studied, but is certainly less than was formerly thought. There are some hopes entertained that by crossing these some results of value may be obtained, but the success along this line is at present small. Kavangire appears to be the best for crossing purposes.

THE INHERITANCE OF CHARACTERS ON THE SUGARCANE.

Unfortunately, next to nothing is known in this matter and this is put down by the author to the complicated hybridization of the cultivated sugarcanes. But some of the results obtained during the long study of seedlings at Pasoeroean are considered to be worth recording. In the first place, BANNIER is very careful in guarding against the assumption, which, he states, is met with among some workers in cane breeding, that the different parents pass on their characters in equal degree. Thus, it is wholly erroneous to imagine that, in a cross between Glagah and a tropical

cane, half of the seedlings will resemble each parent, or that in thrice ennobled Glagah the proportion would be one-eighth to seven-eighths. As a matter of fact, when Glagah is crossed with a tropical cane, very many seedlings of the batch differ little from it, others are intermediate, while very few show any strong likeness to the tropical parent. All kinds of cane exhibit very great variations among their offspring, and certain kinds transmit their own characters much more strongly than others: and, since a great number of parents have been used in crossing for many years at Pasoeroean, certain conclusions have been arrived at in this respect. Some of these are given in the following pages, and it is thought that the information given will be of use as a guide in deciding on the year's crossing programme. BANNIER'S list is here summarized, as useful information is given regarding the behaviour on crossing of a large number of well known canes.

100 POJ*: very few seedlings are obtained in the batches with this cane as mother, and usually with poor habit: these flower heavily, and the sugar is low, and very seldom even reasonably good. Therefore 100 POJ is not used for the production of commercial canes, but rather for the study of others which are also early flowering and male fertile.

2194 POJ: usually flowers heavily and very early: it is tall, and this character is handed on to its few descendants: they generally have a very good habit, but little thickness: internally very solid, but with many cracks and low sugar. Therefore 2194 POJ is seldom used for crossing.

2354 POJ: like 2364 POJ, this cane is pre-eminent as a disease resistant mother of Kassoer origin: its seedlings inherit its thinness: neat in habit and not very free flowering, like the parent: sugar usually sufficient, but the chief defect is the low weight of cane.

2364 POJ: used in a great number of combinations during the last ten years, passing almost all of its good characters on: the number of seedlings is usually small, but more when raised at Malang. The most desirable characters of the seedlings are: moderate thickness (greater than in the parent), sufficient to very good length, long, straight joints, strong root system and almost always good sugar. The defects are heavy flowering and consequent pithiness, and these characters should be specially noted in selection. The best male parents for this cane, thus far, are EK 28 and SW 111.

2722 POJ: often used as mother plant of thrice ennobled Glagah. In the seedlings, the canes are long and very heavy, but with the thickened nodes of the parent, and thus have a less handsome appearance: amount of flowering very variable, and usually solid stemmed. Crossed with all possible tropical parents, the seedlings have sufficient to very high sugar content.

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* In these short descriptions, the writer found it difficult to get at the exact meaning of some of the words, *e.g.*, knokig (bony), grof (coarse), beschaafd (polished). The first two are not usually applied to sugarcanes; and in the present paper the three words are translated "with thickened nodes" "rough" and "neat" respectively.

2725 POJ : there are many descendants from this mother, but with very few good characters : often rough and with nodes thickened : flowering very heavily and quickly becoming pithy, and sugar only moderate : buds stand out and easily start shooting.

2780 POJ: used regularly as mother during recent years, because the descendants usually have good form. They have long and very heavy canes, but joints a little zigzag : flowering small, but a distinct hollow in the stem : sugar very variable. As 2780 POJ is itself low in sugar, it should only be crossed with rich canes.

2802 POJ: seedlings stand out because of their neat appearance : straight and cylindrical and with little flowering : sugar sufficient to good. The great defect is thinness, therefore best crossed with thick fathers,, preferably with high sugar, such as Bandjarmasin hitam, Preanger, and Socrat Banteng.

2806 POJ: this seedling hands down the typical characters of its Chunnee ancestor, good sugar, great susceptibility to mosaic and pithiness, to its seedl ngs. Their appearance is usually good : thicker and heavier than 2806 POJ itself : joints zigzag and frequent cracks and protruding root eyes : flowering consistently heavy, and the tendency for the mother shoot, to develop more rapidly than the tillers, strongly inherited. This seedling is only used in crossing with Kassoer in order to increase the resistance to mosaic.

2822 POJ : flowers heavily and for a long time, therefore much used as a father because of its fertile anthers and producing large batches of seedlings if the mother offers no hindrance. The inheritance of characters in the seedlings is very variable : they have moderate sugar, sometimes very low or very high : similarly with the amount of flowering and pithiness form : often good, straight and very thick, but sometimes with enlarged nodes : the violet colour of the father often seen in seedlings.

2836 POJ : used in very many crossings as mother, as it is very thick, with good length and handsome appearance—characters which are found in many of its seedlings, but, with this habit, they also inherit low sugar content. All of these characters are inherited from Ardjoeno, a cane which hands them down strongly, and thus 2836 POJ is unsuited for crossing.

2853 POJ : from a cross between a "self-made Kassoer" and Striped Preanger. For a grandchild of Glagah it is surprisingly thick, and this character is freely passed on to its seedlings : in these, the joints are often swollen and deformed, and the canes crooked and weak (slap), besides which, the tillering is poor. The sugar content is, however, for a thrice ennob'ed Glagah, very high ; and for this reason the seedling, which is sometimes male fertile and sometimes not, is much used in crossing.

2875 POJ: of great value in crossing work : its own characters are not so good as those of 2878 and 2883 POJ, but it transmits better characters to its seedlings than these do. The habit of the seedlings is often very fine (mooi), while the thickness and length of the canes are sufficient : usually long jointed, but flowering occurs

in some : sugar mostly good. The number of seedlings in the batches is uniformly high.

2883 POJ : batches small, even when crossed with fertile fathers : the few descendants are usually rough and deformed : flowering is variable and the sugar is not high : very often pithy, although 2883 POJ itself appears solid enough.

2887 POJ : A valued mother, usually producing large batches of seedlings. In these there is great variability, some being very poor and some with very good habit : thickness usually sufficient, but tops often suffering from pithiness : sugar also very variable, but good juice not infrequent. The seedling certainly has good characters, which may be handed down to its descendants.

2914 POJ : attracts attention because of its abnormally long and handsome, upright canes, which are found in many of its descendants ; but their canes have small thickness and low sugar. Therefore this seedling is unsuited for crossing purposes.

247 B : greatly used as father in early years, but with small permanent result : seedlings often rough and very heavily flowering : the zigzag canes and many cracks are also handed down : sugar very variable, but rarely high. The percentage of good seedlings with 247 B as father is small in the batches.

DI 52 : usually with little fertile pollen, and when used as mother results never good, while when selfed the seedlings usually misformed dwarfs. In later years it has been found that, when grown at Malang, fertile pollen is produced, and therefore it has been tried as father. The results at present are few, but it already appears that the good sugar of the parent is transmitted in the offspring, which also have a very good habit.

EK 2 : not well suited for crossing, because of the deformed character of the canes and the projecting buds, transmitted by the father. Plants with splits also, often met with in the batches of seedlings : sugar variable, but may be very high sometimes : the bad habit is, however, a serious defect.

EK 28 : one of the most useful among the fathers : fertility of the pollen often very low, but greater at Malang, hence large batches in this place. EK 28 often transmits a good habit, yet the number of worthless seedlings is large : sugar is usually good, but heavy flowering is met with, and is a defect : late ripening is also handed down.

SW 3 : as with SW 111, only suited for crossing with thick mothers : thinness a character of very many of its seedlings, and sometimes unevenness added. Yet the habit is not bad : length of cane is usually sufficient and the joint formation often better than in the parent (see Batjan at the end). Sometimes the canes are weak : flowering varies, but does not occur in very many : sugar is not bad, but good juice is, nevertheless, rare.

SW 111 : practically as SW 3, but certain results better : seedlings also thin, but of good habit and usually straight and long-jointed : flowering, however,

copious : sugar not bad and sometimes very good, and early ripening seen in many. For this reason SW 111 is readily used in crossing.

Bandjarmasin hitam : flowering rare at Pasoeroean and little pollen, but both better at Malang : fertility very high there at the beginning of the season but very low towards the end. So this kind can be used as father or as mother : its thickness very strongly inherited, often with good sugar : habit, however, rough : eyes stand out strongly, and canes are often dry in centre : batches usually small.

Black Cheribon : much used in early years, but chiefly with Chunnee and its descendants : the characters of the latter strongly dominate in the seedlings, and therefore little is known about the inheritance in Black Cheribon. The fertility of its pollen very low or nil at Pasoeroean, but moderately high at Malang, especially in the beginning of the flowering season : it was generally used as mother, and then large batches obtained. In the seedlings the variability of the characters of the female parent great : habit not bad, and so with sugar : but in all respects Black Cheribon is less useful than Preanger.

Preanger : fertility of pollen practically as in Bandjarmasin hitam, and batches not large : habit very neat : canes not very long, but joints well formed : sugar varies a great deal, but sometimes very satisfactorily high. This variety transmits its good qualities better than other original canes.

Ardjoeno : characters referred to under 2836 POJ : descendants, have thick and heavy canes, and short and swollen joints : plants rough and often very weak, but percentage of seedlings with good habit high : sugar specially low : flowering not very heavy.

Green German New Guinea, Sampang A and Sawoe Kroepoek : related to one another, and similar as to transmission of characters to descendants. These have good habit, but moderate to very low sugar is seen in many seedlings : canes usually very thick, straight and cylindrical : length sufficient : flowering very variable : buds usually flat on stem. Sampang A stands out in some combinations, in others the remaining two, but the batches with Sampang A as father are largest. When these canes are used for fourth ennobling of Glagah, some plants are found with very satisfactory sugar.

Lahaina : much valued as mother : flowering little in the plains, but better at Malang. The cane only to be used in the green variant, as the chlorophyll-free places on the stem are continued into the inflorescence : many ovaries are without chlorophyll, and give colourless seedlings which soon die. Transmission of high sugar is very strong, but so is that of the weak roots, and the susceptibility to *sereh* and mosaic. In the seedlings, cane habit heavy, but sometimes rough and crooked or weak : joints often short and deformed, and root eyes quickly protruding : flowering rare. Because of high sugar content Lahiana is desirable in crossing.

Loethers : stands out because of the high sugar in its descendants : habit usually not very good (mooi) : canes moderately thick, but weak, rough and zigzag : many plants have pointed and sprouting buds : heavy flowering largely transmitted, with

thin tops and much pithiness. Sometimes the habit is distinctly better, and therefore Loethers occupies an enviable position in crossing.

Fiji : to a certain degree comparable with the Green German New Guinea group : its good habits found in many seedlings : canes usually very long and thick, but with zigzag joints : eyes sometimes much swollen and cracks not rare. When used as father, large batches are obtained, in which the seedlings are heavy and have little flowering. The transmission of good habit is perhaps less than in the group above mentioned, but that of high sugar is greater. This is not high in Fiji itself, and even less in the seedlings, but those with sufficient sugar are not rare.

Batjan : as in Lahaina the striped form is not used, and for the same reason. Habit and sugar content largely transmitted, the canes being consistently very thin, often weak, but very long : many show the peculiar swelling joints of Batjan. Flowering variably and many with the same susceptibility to disease as the parent : sugar content well transmitted, mostly good and sometimes high. As father, Batjan comes a little behind its descendants S and especially SW 111. For this cane to be of use, it must be crossed with thick mothers.

III. Summary of the Results obtained, 1893-1925.

This portion of BANNIER'S paper is devoted to the details of the crossing work during the whole period, and these are presented in tabular form. The Tables are preceded by short statements concerning them, but it will suffice, in the absence of the Tables themselves, merely to refer to the nature of the matter dealt with.

Table I gives, for each year, the numbers of arrows sown, combinations of parents, combinations used for the first time, successful ones, *i.e.*, where at least ten seedlings were obtained, and seedlings planted out. The totals for the whole period were : 6,884 arrows sown, 2,825 different combinations used, and 392,871 seedlings planted out. Table II gives, for the period 1912-1925, an analysis of the same details for each year, separating artificial crosses from those obtained by wind or selfing. In Table III, the combinations of parents are grouped into ten divisions as follows : tropical canes only, ennobling Chunnee, twice ennobling Chunnee, thrice ennobling Chunnee, twice ennobling Glagah, thrice ennobling Glagah, four times ennobling Glagah, combinations between ennobled Chunnee and ennobled Glagah, *Saccharum sinense*, and others.

Table IV gives the details of the various combinations used in each year, and the results obtained in each combination : numbers of arrows harvested, seedlings planted out, selected at the end of the first year, at the end of the second year, and at the end of the third year, *i.e.*, added to the POJ collection. This Table, of course, covers many pages (62), and practically forms a diary, year by year, of the crossing work of the Pasoeroean station. Table V has already been referred to, as containing details of the complete POJ collection, with their immediate parentage, and those which are still in the collection at Pasoeroen. Table VI contains curves of the

various combinations for the whole period : tropical canes only, Chunnee ennobling, Glagah ennobling and others. In the latter, are included combinations between Chunnee and Glagah seedlings, the ennobling of *Saccharum sinense*, and again others : this curve is nowhere high. The diagram gives a clear idea of the stage of development at any period. This, in 1925, the crossing programme included about 75 per cent. of Glagah ennobling, 8 per cent. of crosses between tropical canes only, and 17 per cent. of "others," as defined above. This proportion has been practically unaltered since 1918, although a small amount of Chunnee crossing was done at intervals.

C. A. B.

THE TECHNIQUE OF VITAMIN ASSAY.*

When it was found that a diet of pure protein, fat, and carbohydrate with salts and water was incapable of maintaining life in animals unless small quantities of certain natural foods were added, or the content of the diet in the other known constituents, the foundation was laid upon which has been built in the last fifteen years a vast store of knowledge about the properties and occurrence of these unknown accessory food factors or vitamins. At first investigators were concerned with the qualitative distribution of each vitamin, as it was discovered : only later was attention directed to its quantitative estimation in different sources, as the methods of assay became more perfected. These lines of approach to an accurate knowledge are in use to-day, when a new vitamin is discovered, as is shown by the work of Evans and his collaborators on Vitamin E, or the reproductive factor.

It is obviously important from the point of view of dietetics and medicine that the amounts of the vitamins in different food and medicinal products should be accurately known. Such knowledge can be obtained at present only indirectly, since the vitamins have not yet been isolated in pure form, and any fallacies inherent in such a method of assay are greatly enhanced by the fact that, in general, living animals must be used for the test. Hence improvements in technique relate to the use of a standardized animal, bred especially for the purpose, and placed on a diet either deficient solely in the factor to be assayed, or so designated as to enable the observer to obtain a clear-cut response on the part of the animal or even of a given tissue, when the missing factor is added to the diet. Recent improvements in technique are especially noticeable in the case of Vitamin A or the growth-promoting factor, and Vitamin D or the bone-calcifying factor A further interesting development is the use of a colour test, which can be used for the quantitative estimation of Vitamin A, and bids fair in time to replace the laborious growth test on animals altogether.

The details to be followed in the production of a standard breed of rats for the assay of the fat-soluble Vitamins A and D are discussed by H. Chick and H. H. Smith and H. Chick (*Biochem. Jour.*, 1926, Vol. 20, pp. 119,131). The authors were led to their researches by finding unexplained irregularities in the behaviour of the young rats when placed upon the standard basal diet deficient in fat-soluble vitamins. In general, better growth and calcification of the bones were found in summer and autumn than in winter and spring. Neither the degree of illumination to which the animals were exposed nor the constituents of the standard deficient diet were found to be implicated in this variability. It may per-

* Reprinted from *Nature*, No. 2988.

haps be mentioned here that the diet largely used in Great Britain consists of inactivated caseinogen, starch, a hardened vegetable oil, salts and water, together with 'marmite' and lemon juice to supply Vitamins B and C respectively. The caseinogen is inactivated, *i.e.*, any fat-soluble vitamins present are destroyed by heating it to 120°-130°C. for thirty-six hours.

Examination of the diet given to the stock-breeding rats, however, disclosed the possibility of serious variations in the amount of Vitamin D, with smaller changes in the case of Vitamin A, dependent upon seasonal alterations in the content of these vitamins in the fresh milk of the diet. It is well known that the store of fat-soluble vitamins in young rats depends on the previous diet of the mother, especially during pregnancy and lactation. Hence the diet of the stock animals should contain, if possible, a constant and sufficient, but not excessive, quantity of fat-soluble vitamins. This ideal was approached by replacing fresh milk with a dried winter milk towards the end of pregnancy and continuing its use during lactation, and, in the case of the young, during the period elapsing between weaning and placing on the deficient diet. Earlier use of this milk in the mother's diet lowered the store of vitamins too much, so that it became difficult to rear the young. The other constituents of the diet, bread, whole cereals and seeds, fresh raw vegetables, and marmite, with meat twice a week, provided a steady supply of Vitamin A; so that the irregularities in the young rats were probably chiefly caused by variations in their stores of Vitamin D.

The fact that the latter vitamin may be responsible for variations in growth has only recently been realized, with the definite demonstration that Vitamins A and D are distinct accessory food factors. Its importance is demonstrated by the following considerations: the original standard diet deficient in fat-soluble vitamins is deficient in both: cessation of growth may then be due to exhaustion of either, and resumption of growth, on supplementing the diet with a material containing them again to either, or both, of the vitamins present. Hence titrations of Vitamin A may be considerably affected by the presence or absence of Vitamin D from the diet or body of the experimental animal.

This question has been carefully examined by J. C. Drummond, K. H. Coward and J. Hardy (*Biochem. Jour.*, 1925, Vol. 19, p. 1068). The authors found that irradiated cholesterol, which is now known to have marked antirachitic potency, that is, to contain Vitamin D, can, under certain conditions, cause resumption of growth in rats on the standard-deficient diet. But the authors show that this does not mean that by irradiating cholesterol, Vitamin A is generated. In the first place, the colour reactions of irradiated cholesterol are not those usually associated with Vitamin A (this subject is discussed more fully below); secondly, the addition of the irradiated material to the diet only produced resumption of growth when given soon after growth had ceased; later it was without this effect; and thirdly, the resumption of growth was only temporary and could not be maintained by increasing the dose, although small doses of cod-liver oil prevented the de-

cline in weight, in fact, allowed growth to continue. The authors conclude that the store of Vitamin A in the animal is only available in the presence of Vitamin D, and that the irradiated cholesterol supplies the latter and not the former.

Hence in comparing the growth-promoting powers of two materials, one of which contains Vitamins A and D, and the other Vitamin A only, an erroneous idea of their relative contents in Vitamin A can easily be obtained if the animals at the time are suffering from a simultaneous deficiency of Vitamin D. With the former supplement, growth would be dependent on both vitamins together; with the latter, little growth would probably be seen, unless the animals still had a store of Vitamin D, although the Vitamin A content of both materials might be the same. The important conclusion is therefore reached that for the accurate assay of Vitamin A, Vitamin D must be always present in the basal diet. This can be ensured by the addition of irradiated cholesterol to the diet, or by feeding it separately as a daily supplement dissolved in liquid paraffin (Drummond *et al.*), or perhaps more conveniently by using an irradiated hardened vegetable oil as one of the constituents of the diet (H. Chick and M. H. Roscoe, *Biochem. Jour.*, 1926, vol. 20, p. 632). Drummond excludes fats altogether from his latest standard diet, replacing them with starch, but other observers continue to use a diet of the type mentioned above. If the animals are given a diet deficient only in Vitamin A, they continue growing for a longer period than when Vitamin D is also absent; but when growth ceases, a decline in weight rapidly sets in and the supplement containing Vitamin A must be quickly given, if death is to be prevented.

So far we have considered the assay of Vitamin A by means of animal experiments. The difficulties and the time involved lend importance to an alternative possible method, such as a colour test, which can be performed quickly and accurately in a test tube. Two such have been recently described as specific for Vitamin A: the transient blue colour produced by arsenious chloride (Rosenheim and Drummond) and the stable red colour produced by pyrogallol in the presence of a light petroleum solution of trichloracetic acid (W. R. Fearon, *Biochem. Jour.*, 1925, vol. 19, p. 888). The latter, which seemed likely at first to be of great use, was modified by S. G. Willimott and T. Moore (*ibid.*, 1926, vol. 20, p. 869): resorcinol was used instead of pyrogallol, and a saturated solution of benzoyl peroxide in toluene was added to hasten the reaction, the trichloracetic acid being also dissolved in this solvent.

Preliminary experiments showed that the colour was produced by those substances, chiefly oils, in which the presence of Vitamin A is generally accepted, and not by others from which this vitamin is absent. However, a more extensive study by O. Rosenheim and T. A. Webster (*Lancet*, 1926, vol. 2, p. 806) has demonstrated that the test is not specific for Vitamin A: thus, on saponification of an active oil, Vitamin A remains in the unsaponifiable fraction, but the chromogen giving Fearon's reaction passes into the soaps formed, being associated with the unsaturated fatty acids. Again only, fish liver oils give the reaction, where

as the liver oils of birds and mammals contain Vitamin A: body fat may react positively, but negatively to the arsenious chloride reagent. In a biological test, a sardine oil, giving Fearon's reaction, was found to be devoid of the growth-promoting factor, whereas pig's liver fat, although reacting negatively with Fearon's reagent, yet gave as good growth as cod-liver oil—even when only half of the dose of the latter was used. In all cases Vitamin A and the colour reaction with arsenious chloride were found to occur together, in fact, the latter appeared to give a depth of colour roughly proportional to the amount of vitamin disclosed by a growth test. Hence it may be concluded that the colour given by Fearon's reagent is due to some other constituent of the oil than Vitamin A. On the other hand, the arsenious chloride reaction appears to be specific, so far as our present knowledge goes. The drawbacks to the test are the transient nature of the blue colour produced, and the fact that the reagent cannot be used with a solvent.

E. H. Carr and E. A. Price, and T. T. Cocking and E. A. Price have therefore examined a large number of other compounds with the view of selecting a more satisfactory reagent (*Biochem. Jour.*, 1926, vol. 20, p. 497; *Pharm. Jour. and Pharmacist*, 1926, vol. 107, p. 175). At first the substitution of arsenious chloride by a saturated solution of trichloracetic acid in chloroform, as suggested by Rosenheim and Drummond, gave promise of satisfying the necessary requirements, but it was found that the colour production depended on the presence of an impurity in the acid, probably phosgene. The authors finally selected a 30 per cent. solution of antimony trichloride in B.P. chloroform as the most satisfactory reagent so far found: it can be used with a 20 per cent. solution of the oil under test in chloroform, enhancing the accuracy of measuring small quantities of oil. Moreover, the blue colour lasts sufficiently long for a match to be made against the standard glasses of a Lovihond tintometer, and is not interfered with by traces of water or alcohol in the reagents. The colour formed always contains traces of yellow and sometimes also of red.

The real problem which now faces investigators is whether the colour test always gives the same value as the growth test, when both are carried out on a large number of different oils. Some preliminary experiments carried out by S. W. F. Underhill (*Biochem. Jour.* 1926, vol. 20, p. 500) lend hope that this parallelism may be invariably found, in which case the biological assay with its difficulties of animals and time, may be rendered unnecessary, being replaced by the much shorter and probably more accurate colour test.

The titration of Vitamin D or the bone-calcifying antirachitic factor still requires the biological method. Moreover, rickets is not produced in rats on a diet deficient only in fat-soluble vitamins. Although the bones contain less calcium than normally, the picture is one of osteoporosis, so that such a diet is not suitable for this assay (H. Chick and M. H. Roscoe, *v. sup.*). But if the diet is deficient in phosphorus also, rickets occurs. Two such diets have been widely used: one was described by Sherman and Pappenheimer, and consists of pat-

ent flour with the addition of a few salts ; the other we owe to McCollum, its chief ingredients being wheat, maize, gelatin, and wheat gluten with a few added salts. Rosenheim and Webster (*Biochem. Jour.*, 1926, vol. 20, p. 537) , using the former, found that sometimes the control animals failed to develop rickets and traced this irregularity to a small quantity of fat present in the patent flour, which could become 'activated' if the flour was exposed to light. They therefore recommend an extraction of the flour with ether at room temperature for a short period, before it is used in the diet.

The degree of calcification of the bones on these diets can be determined radiologically, histologically or by chemical analysis. Improvements in the presentation of results by the last method are described by Chick and Roscoe (*Biochem. Jour.*, 1926, vol. 20, p. 137, and with V. Kovenchevsky, *ibid.*, p. 622). More clear-cut results are obtained if, in addition to the ash, the fat of the bones is also estimated. Omission of this precaution may suggest that a substance under test has improved the calcification slightly, whereas it has only reduced the fat content, possibly by improving the nutrition of the animals quite apart from its content in Vitamin D, if any is present at all. Normal bones contained about 2 per cent. of fat, rickety 4 per cent., and osteoporotic 10 per cent : the ash content respectively was found to be 34 per cent., 11 per cent., and 25 per cent. for comparable bones. The authors suggest that the ratio of the ash to the organic residue (that is, the difference between the weight of the bone and the sum of the weights of water, fat and mineral constituents) may give a useful index of the degree of calcification and of rickets. Normally, it is about 1·5, in osteoporosis 0·9-1·2 and in rickets 0·4-0·8.

The more accurate the methods of assay, the better is our knowledge of the value of different food or medicinal products, and the greater is the hope of developing methods for the isolation of the accessory food factors in a pure form.

NOTES

DEFECTIVE BEARING IN PLUM.

THE plum (*Prunus communis* Hud., var. *insitutia*) is a member of the Rosaceæ family and is related to the group of plants to which almonds, peaches, apricots, loquats and cherry belong. In India it is grown in almost all gardens of any importance and its fruit is eaten and liked by all classes. Most of the varieties, however, are hardly palatable except when cooked or preserved, and for this purpose, as Cameron [1] states, they are equal to the finest European kinds.

The uncertain bearing and defective setting in some of the varieties of Rosaceæ family is well known. But in spite of the presence of well established gardens, like those of Lahore, Saharanpur, Lucknow, Calcutta, Bangalore, Nagpur, etc., little or no record about the causes of this defective bearing in plums is found.

At Pusa some fruit experiments [2] were laid down in 1905 by the then Imperial Economic Botanist and the following varieties of plums were tried :—

Botanical gardens, Saharanpur. Dwarf Early Yellow, Early Large Red, Early Round, Alucha Purple, Alucha Red, Alucha Yellow, Alucha Black, Alubukhara, Alubukhara Small, Kabul Green.

Cultivators' garden, Calcutta. Alucha Large, Alubukhara, Large Red, Large yellow.

Lal Bagh, Bangalore. Bangalore variety.

After 5 years' study the results were summarised as follows[3]:—" A fairly large collection of peaches and plums was made at Pusa during 1905 and 1906 and several crops have beeen obtained. Of these varieties only the early ones are of any use for Bihar. Heavy crops have been borne by the early kinds, but the late sorts without exception have set no fruits. A profusion of flowers is obtained but no setting takes place. This appears to be due to the high temperature and low humidity which prevail (on account of the dry west winds) at the time these late varieties come into flower. Copious irrigation just before flowering has no effect, no setting being obtained, however the soil moisture is regulated. Of the varieties of plums and peaches which set fruit, the most satisfactory are the earliest of all these which ripen in May. The somewhat later varieties are not so satisfactory

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[1] Ferminger's Manual of Gardening by Cameron, 10th Edn., 1890, p. 246.

[2] First Report on the Fruit Experiments at Pusa, by A. Howard, *Agri. Res. Inst., Pusa Bull.* 4, 1907, p. 30.

[3] Second Report on the Fruit Experiments at Pusa, by A. Howard, *Agri. Res. Inst., Pusa Bull.* 16 of 1910, p. 19.

on account of the rise in humidity which often takes place during the early part of June when the moist east winds, which precede the monsoon, set in. Under such circumstances ripening peaches and plums rapidly deteriorate and fruit in this condition will not travel long distances."

After forming the above opinion. the experiment was discontinued and all the varieties were discarded except the following :—

(1) Black Small—An early plant which was very prolific having small and black fruits of inferior quality, ripening in early May.
(2) Large Red—A late plant, moderate in bearing, with large red fruits of good quality ripening in the last week of May.

One plant of each of the above varieties was selected as progenator and three years elapsed in propagating sufficient number of plants from those individuals to start a new experiment. In 1914 these plants were used in filling up a line of 24 plants for an experiment which was started by the then Imperial Economic Botanist to investigate the influence of grass on fruit trees.

In this work two main problems were kept in view, namely, (1) why grass is so injurious to fruit trees, and (2) the nature of the weapons by which forest trees vanquish grass. The results of these experiments were published in the *Proceedings of the Royal Society*, B. Vol. 97, No. B. 683 and were also reprinted in the *Agricultural Journal of India*, Vol. XX, 1925, pages 285-317, under the title of "The Effect of Grass on Trees" by Albert Howard, C.I.E., M.A.

The above experiment, of course, was not devised to investigate the causes of defective setting in plums; no one could fail to notice, however, that every plant of the early variety (Black Small) bore nicely, while all the plants of the late variety (Large Yellow) were almost barren. The parent of these late plants which was surrounded by other varieties of plums, though shy in bearing, was giving some fruit at least every year, but grafts taken from it totally refused to set, save that in some years two or three fruits could be seen on some plants.

In 1921 when the writer was carrying out details of the above mentioned grass experiments under the direction of the Howards, he observed that sterility in the late variety was due to—

(1) The defective stamens which do not form pollen at all.
(2) The late flowering which prevents pollination from the early variety, the flowering period of which has ceased before the late variety comes into flower.

It was evident that if a variety with good pollen of the same flowering season could be grown near the large red, it should set fruits. The investigation of this idea, however, was not put into action till 1925 when an experiment was started. The writer was sent to Saharanpur and Delhi to select suitable varieties of plums. The newly imported plants were transplanted in a separate nursery on the 25th

November, 1925, so that the study of their pollination could be thoroughly made and the most suitable plants selected for interplantation as pollinators between the old plants. The new plants produced some flowers for the first time in March 1927. At Pusa there are only four plants of large red and one plant of Black Small varieties, a remnant of Mr. Howard's grass experiment. It is interesting to note that though the actual experiment has not yet been started, these four old plants of the large red variety have simultaneously set some fruits this year. It is evident that the pollen of the new varieties was carried by bees and other pollinating insects to the flowers of the old plants which are about 200 feet apart from the nursery and has brought about this setting. Though the average number of fruits set per plant is not more than 60, still it is very encouraging, considering that the new plants were very small and could produce a limited number of flowers only.

It is hoped that, when the actual experiment is started and the new varieties planted near the old trees, normal setting will take place.

On studying the literature on the subject, it was found that a lot of work has already been done in America [1, 2, 3] about plum pollination. In California plum varieties have been classified into self-fertile and self-sterile groups, and it has been established that cross-pollination in plum is necessary owing to the defectiveness of flower parts and the sterilty of certain varieties towards their own pollen. Varieties which are effective pollinizers and suitable for interplantation have been isolated. It has been proved that to secure good setting suitable varieties should be closely interplanted or scions of suitable varieties should be set into the tops of the trees which do not bear satisfactory crop of fruits. Comparatively, very little work has been done in India on the pollinatoin of the Rosaceæ family and there is a vast field for investigation for those who are interested in the subject. [ABDUR RAHMAN KHAN.]

NOTE ON THE LOSS OF WEIGHT OF ONIONS ON STORAGE AT PUSA.

The onion crop on certain experimental plots was harvested at the beginning of June 1927. It was considered that useful information might be obtained by keeping a portion of the crop till the following cold weather and ascertaining the loss due to rotting, dryage, etc.

Seven maunds of onions were stored on racks, in single layers, and 47½ seers were kept in six small baskets, in a godown. The onions were examined at intervals of about ten days, and the rotten ones removed and weighed.

Most of the onions were sprouting when the final weight was taken, in the middle of November.

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[1] The Pollination of Plums. *Vermount Agri. Expt. Stn., Bull.* 53, 1896.
[2] Plum Pollination. *Bull.* 310, 1919, *Berkeley, California.*
[3] Further Experiments in Plum Pollination. *Bull.* 352, *Berkeley, California.*

The onions on the racks had dwindled to 2 maunds 37 seers, showing a loss of 58 per cent., and those in the baskets to 25¾ seers, a loss of 46 per cent.

The weights of rotten onions removed were 5·5 per cent. of the initial weight stored on the racks, and 13·1 per cent. of that stored in the baskets. [J. H. WALTON.]

THE NITROGEN INDUSTRY.*

THE original German edition of this work † was published in 1923. It contained practically all the information which could be obtained from the literature up to March, 1921. It has been the author's intention to make it a standard work by including a large number of economic data and a detailed survey of the literature. Vol. 1 contains a short general introduction and then a historical account of the nitrogen industry in each country of the world. Vol. 2 gives a technical description of the processes used in the nitrogen industry. The author has also included allied processes which may be important from their economic effect on the main industry. There are very complete indexes, bibliography, and list of patents.

In order to bring the first German edition up-to-date for translation, there is at the end of each chapter a supplement containing new matter covering the years 1921-1924, and a foreword of seventeen pages has been written by Dr. J. F. Crowley. The supplements consist, for the most part, of bald references to the literature and make an unsatisfactory ending to each chapter, but Dr. Crowley's foreword successfully summarises the position of the industry.

The importance of nitrogen in commerce arose during the Middle Ages from the use of saltpetre in making gunpowder. The nitrogen problem was as acute in France during the Napoleonic wars as in Germany during the late War. Prevented by the blockade from importing adequate supplies of nitre, France had resource to nitrate plantations (saltpetrières), which were administered by a State department. In these plantations heaps of animal and vegetable refuse were allowed to rot for months until covered with a layer of saltpetre. But after the Napoleonic wars, when swords were turned to ploughshares, inorganic nitrogen was not turned to agriculture. It was not until about 1840 that Liebig showed that inorganic nitrogen compounds were important soil fertilizers. From that time the use of inorganic nitrogen in agriculture has grown steadily. At first Chile nitrate was the sole source of supply; then came, in addition, ammonium sulphate obtained from coal; and within the last twenty-five years synthetic nitrogen compounds—nitrate of lime, cyanamide, and ammonia. The development of the synthetic nitrogen industry took place first where electrical power could be obtained cheaply—principally in Norway, because the arc processes absorbed much electrical energy.

* Reprinted from *Nature*, No. 3017.

† The Atmospheric Nitrogen Industry: with special consideration of the production of Ammonia and Nitric Acid, by Dr. Bruno Walser. Translated by Dr. Ernest Fyleman, Vol. I, pp. XXVI, 330; Vol. II, pp. 331-746. (London; F. & A. Churchill.) Price, 42*s*. net.

Some years before the War, Germany had become anxious to produce synthetic nitrogen fertilizers for her soil. A continental nation with no food-producing colonies, that country was attempting to produce all the food it required. Tariffs were put on imported food, but Germany had to import large quantities of nitrogen, and in 1913 it absorbed 27 per cent. of the total nitrate exported from Chile, as well as nitrate of lime from Norway and sulphate of ammonia from its own coal industries. During this year (1913), 32 per cent. of the world's production of inorganic nitrogen was used by German agriculturists. How different were the conditions in Great Britain with free trade, large investments abroad, food-producing colonies, and a large navy.

When the War broke out, Germany, expecting a short war, appears to have attached no importance to the supply of nitrogen for explosives. Later, when the blockade became serious, Germany looked first to her cyanamide factories for nitrogen, and only later did the German Government realize the possibilities of the Haber Bosch process of ammonia synthesis which had just been established in 1913. Two large factories were erected to provide the war requirements. Since the War the German synthetic ammonia factories have been utilized for the production of fertilisers, and works using somewhat similar processes are now active in other countries—England, America, Italy, France, and Belgium. Some of these (England and America) are well established and are already a commercial success. Others are still passing through tribulations and troubles.

The tendency of modern industry is to build large factories, because greater efficiency is obtained with large machines than with small ones, and the cost of labour for a given output usually decreases as the size of the unit plant increases. But more important still is the advantage of better scientific and technical control of processes which can be obtained in a large factory. Dr. Crowley in his introduction seems to attach great importance to a claim of simplicity of one process (Casale), though it is difficult to find the basis of the claim. He states : " On a visit to an important synthetic ammonia plant paid some twelve months ago, the writer found that the whole plant was being operated under the direct supervision of the engineer responsible for the running of the power station, and that no chemists were employed." It does not seem probable that this plant will long survive in competition with plants controlled by the best technically trained men of to-day.

PROTECTION OF COCONUT PALMS IN FRENCH INDIA.

By an order dated the 1st August, 1927, the Minister of the French colonies has prohibited in the French Settlements in India the importation by sea, sale, warehousing and transit of coconut plants, coconuts, coconut leaves and all materials containing parasites which attack this palm.

THE EFFECT OF TEMPERATURE AND HUMIDITY ON COTTON SPINNING.

THE following is the summary of the Indian Central Cotton Committee Bulletin No. 9 (Technological Series No. 4) on the subject :—

Tests are described to determine what differences are experienced when cotton-spinning is carried out under different conditions of temperature and humidity. The results obtained by Sir Benjamin Dobson (1894) are discussed in some detail and reasons advanced for showing that they are not entirely satisfactory. The climatic conditions which prevail in Bombay are considered at length, tables being given to show the mean temperature and mean relative humidity normally experienced for each hour of the day for every day of the year ; a table is also given showing the frequency of occurrence of days of specified minimum humidity during the cold weather period in Bombay.

Spinning tests have been carried out on seven different cottons, each of which has been spun in duplicate into three counts of yarn under three different sets of physical conditions of temperature and humidity. The spinning conditions are described as :

(1) Medium-Dry, *i.e.*, conditions obtained when the outside relative humidity is at its lowest ;
(2) Normal, *i.e.*, conditions such that the temperature is about (but not below) 80° F. and the relative humidity is about 65 per cent. (but never below 60 per cent.) ; and
(3) Monsoon, *i.e.*, conditions in which the temperature is 90° F. and the relative humidity is about 70 per cent.

Observations were made as to the several conditions for (1) comfort in working ; (2) workability of the material ; (3) appearance of the yarn ; (4) strength of the yarn. Each of the two lots of each cotton was spun into three counts of yarn under each set of conditions ; and each of the yarns thus obtained was subjected to 50 lea tests, 100 tests for single thread strength and extension, and 80 twist tests. The conclusions drawn from these tests are :

(1) for comfort, the normal conditions are more satisfactory than either of the extreme conditions ;
(2) for workability of the material, the medium-dry conditions are not quite satisfactory in the card room, whereas the normal and monsoon conditions are satisfactory throughout ;
(3) the yarn spun under medium-dry conditions is the least satisfactory in appearance, and that spun under the monsoon conditions the most satisfactory, but these differences practically disappear when the yarn is conditioned ;
(4) within the limits of temperature and humidity within which these tests have been carried out, it is impossible to lay down any hard and fast

rule as to the conditions (medium-dry, normal, or monsoon) which give rise to the strongest yarns, the differences for the most part being inappreciable ;

(5) in general, it may be taken that the processing of the material in cotton-spinning and the quality of the spun yarn are not seriously affected by the spinning processes being carried out at relative humidities as low as 40 per cent. ; but that, taking all things together, the normal conditions are probably best for carrying out cotton-spinning tests ;

(6) Bombay conditions are practically ideal for the processing of the material in cotton-spinning.

THE EFFECT OF SUBJECTING COTTON TO REPEATED BLOW-ROOM TREATMENT.

THE following is the summary of the Indian Central Cotton Committee Bulletin 10 (Technological Series No. 5) on the subject :—

A description is given of tests carried out to determine the effect of repeated treatment in the Crighton opener, or in the scutcher, of baled cottons containing a large percentage of foreign matter. Duplicate lots of three different cottons, *viz.*, 289F, 285F, Hagari 25, were respectively given 2, 3,and 4 treatments in the Crighton opener. One of the cottons was also given the normal treatment in the Crighton opener, but successive samples were passed through the scutcher 3, 4, and 5 times respectively. Each lot of each cotton subjected to each treatment has been spun into three different counts of yarn. Observations were made as to the behaviour of the cotton during working, and a record was kept of the number of breakages sustained on the ring frame during the spinning of each yarn. Spinning test results are given showing the waste percentages and the various yarn-test results, each yarn being subjected to 50 lea tests, 100 tests of single thread strength and extension, and 80 twist tests ; each yarn was also classified according to its evenness and neppiness.

The results of the tests show that three or four treatments in the Crighton opener, as compared with the normal two treatments, yield an increase of only about three-quarters per cent. in the total waste for each additional treatment ; otherwise, the extra treatment makes practically no difference either to the behaviour in spinning, to the appearance of the yarn—including its evenness and neppiness—or to the strength of the yarn. The effect of additional scutching was very similar to that of additional Crighton-opening.

It is pointed out that the results relate to small scale tests and that when cotton is being passed through in bulk somewhat different results might be experienced ; in particular, if there should be a lack of uniformity in the flow of the cotton, such as to cause an intermittent accumulation in the Crighton opener, damage to the cotton staple might ensue. Reference is also made to the possible effects of different

beater speeds, settings, and formation of the grids of the opener. The chief conclusions drawn are : (1) that so long as the cotton passes uniformly through the blow-room, repeated opening or scutching effects a slight improvement in cleaning without detriment to the strength of the yarn ; and (2) that once cotton containing foreign matter is pressed into bale form, it may be very difficult, if not impossib'e, to remove the foreign matter completely—especially if it consists of fragments of seed-coat—so that the appearance and value of the yarn suffer accordingly.

TECHNOLOGICAL REPORTS ON STANDARD INDIAN COTTONS, 1927.

THE following is the Summary of the Indian Central Cotton Committee Bulletin 11 (Technological Series No. 6) on the subject :—

Reports are given on eighteen standard Indian cottons and three American cottons tested for comparative purposes. Each report is divided into the following five sections :—

I. Agricultural Details. II. Grader's Report. III. Fibre Particulars. IV. Spinning Tests. V. Remarks. The agricultural details provide some idea of the relation of the standard cotton to the commercial crop of the district, the history of its introduction, the soil and climatic conditions in which it is grown, and the magnitude of the crop of the new cotton. The Grader's report shows his estimate of various characters of commercial importance. The fibre particulars include the fibre-length, the fibre-length distribution (also shown graphically), the fibre-strength, the fibre-rigidity, the fibre-weight, the fibre-width, and the number of natural twists in the fibre. The " spinning tests " section comprises a description of the treatment given in the spinning machinery, the Spinning Master's report on the cotton, a yarn examination report for evenness and neppiness, together with a table of spinning test results, including the aste percentages, the ring frame particulars, the results of lea and single thread tests, and figures showing the physical conditions of temperature and humidity prevailing during the spinning and testing respectively. The " remarks " section briefly summarizes the main conclusions which may be drawn from the results of the fibre-tests, the amount of waste made, the number of yarn breakages in the ring frame, and the results of the various tests and examinations to which the yarns are subjected,—particularly with reference to the question of seasonal variation.

The reports are prefaced by a note which describes the objects of the tests as being, generally, to accumulate data for the investigation of the methods of determining the intrinsic value of a cotton, and specifically : (i) to prepare a series of standards by which to judge other cottons, particularly new cottons produced by cotton breeders ; (ii) to determine the extent to which these standard cottons are affected by seasonal variations ; (iii) to determine the minimum weight on which a spinning test can be carried out satisfactorily ; and (iv) to assist in the marketing of

these cottons by providing the cotton trade with detailed information concerning them.

It is pointed out that for spinning purposes the intrinsic value of a cotton comprises three factors—the quality of yarn which can be made from the cotton, the behaviour of the cotton during spinning, and the amount of waste to which the cotton gives rise.

The remainder of the prefatory note is chiefly devoted to a fairly detailed discussion of the following :—

(1) The reasons why it is important to know what is the minimum weight of cotton necessary for a spinning test :—

The chief reason is that cotton breeders are thereby enabled to have spinning tests on their new strains made at the earliest possible stage.

(2) The validity of adopting a special routine for spinning tests on small samples :

It is explained that the special routine at the Technological Laboratory has been adopted so as to give such a treatment in the spinning test on a small sample that the results will provide a valuable guide to what may be expected when the cotton is spun under practical conditions. From a detailed consideration of the spinning processes it is concluded that on the whole the results obtained should approximate to those obtained under the best mill conditions.

(3) The special routine adopted at the Technological Laboratory for spinning tests on small samples :

This routine is described in great detail: full particulars are given of the machinery, and of the speeds and draft employed therein, together with the actual *modus operandi* in a spinning test. Two methods of indicating spinning value are discussed ; that adopted consists in spinning the sample in duplicate lots, each of which is spun so as to provide three types of yarn ; a conclusion is then drawn as to the highest count of warp yarn of moderate twist for which the given sample is suitable, based on the performance of the cotton during the various spinning processes, the numbers of yarn breakages in the ring frame, and the yarn test results. Standards are laid down both for twist and strength and the basis and operation of these standards explained.

(4) The various examinations and tests to which the raw cottons and the spun yarns are subjected :

The extent of these tests will be clear from the nature of the individual reports referred to above. Various details of the fibre and yarn tests are described and particulars given of novel methods of twist testing and single thread testing. The method of sampling in yarn-testing is described, and the comparative merits of the lea and single thread tests are discussed.

(5) The various general results which have been obtained in the course of the tests :

This general discussion is confined to four points as under :

(*i*) *The characteristics of the various standard Indian cottons.* The cottons a e divided into four classes :

CLASS I, suitable for 30's and over :

Bombay.—Dharwar 1, Gadag 1, Surat 1027 A. L. F.
Punjab.—Punjab-Americans 285F and 289F.
United Provinces.—Cawnpore-American C. A. 9.
Madras.—Coimbatore Co. 1 (Cambodia 295), Nandyal 14.

CLASS II, suitable for counts between 20's and 30's :

Punjab.—Punjab-American 4F.
Madras.—Hagari 25, Karunganni C.
Hyderabad.—Umri Bani.

CLASS III, suitable for counts between 10's and 20's :

Bombay.—Wagad 4, Wagad 8.
United Provinces.—Cawnpore K. 22, Bundelkhand J. N. 1.

CLASS IV, suitable for counts below 10's :

Punjab.—Mollisoni.
United Provinces.—Aligarh A. 19.

Attention is drawn to the fact that the hand-stapling method of the Grades appears to exaggerate the differences between the staple lengths of fine and coarse cottons, and reasons are advanced to explain the discrepancies between his estimates and the Sorter determinations.

(*ii*) *The seasonal variation of the standard Indian cottons.* Tables are given showing the seasonal variation in mean fibre-length and in highest suitable counts over four seasons ; three cottons (285F, Co. 1, and Hagari 25) show a maximum seasonal variation between 15 and 25 per cent. in fibre-length, and four cottons (Gadag 1, 289F, Mollisoni, and Co. 1) show a maximum seasonal variation of more than 20 per cent. in highest suitable counts. There is no evidence to show that any of the cottons has undergone any deterioration of type.

(*iii*) *The relation between fibre characters and spinning value.* The relation is discussed for each fibre-property in turn, and it is shown that when the cottons are arranged in the order of highest suitable counts, there is discernible for all properties except fibre-strength a fairly well-marked general trend more or less parallel to that of the counts : no such general trend is discernible for the ratio of fibre-strength to fibre-weight per inch, or for the ratio of fibre-rigidity to the square of the fibre-weight

per inch. There are so many individual exceptions to each general trend that it is concluded that no single fibre-property can serve as a universal criterion to indicate the highest suitable counts into which a cotton can be spun.

(*iv*) *The minimum weight of cotton needed for a trustworthy spinning test.* The review of the several individual results shows that no material difference is obtained, except in card room loss and in neppiness, whatever be the weight of the sample, even if it be as low as 2 lb. The differences in card room loss are traced to the quantity of cotton needed to load the card-wire, and this is found to amount to 0·1 lb.; the decreased neppiness of 2-lb. samples is due to the greater efficiency of the card in removing neps just after it has been cleaned. The conclusion is drawn that the procedure which has been adopted for testing small samples submitted by cotton breeders, *viz.*, making spinning tests in duplicate on lots weighing only 5 lb. each, is completely justified within the range of counts possible with Indian cottons, *i.e.*, up to 40's.

COTTON NOTES.

THROUGH the courtesy of the British Cotton Industry Research Association, the Secretary, Indian Central Cotton Committee, has sent the following abstracts for publication :—

EGYPTIAN COTTON PLANT—GROWTH, BUD-SHEDDING, AND FLOWER PRODUCTION.

Analyses of elongation and flowering curves obtained over the period 1920-24 indicate that daily fluctuations in rate of elongation can have little connection with fluctuations in subsequent rate of flowering Shedding experiments covering the same period show that the flowering curve fluctuations are determined by bud-shedding. Minimum temperatures in some cases show a marked correlation with elongation, though this is not invariable. High temperatures may have a temporarily depressing effect on rate of elongation. Abnormally high temperatures may possibly depress the rate of flowering after an interval of 30 days or more. Irrigation is generally followed by an increase in rate of elongation. Screen evaporation is closely connected with maximum screen temperatures, but neither of these recorded factors has been correlated with elongation. The height of the Nile as recorded at Rodah gauge is not connected with the rate of flowering. Daily fluctuations in flowering depend, though indirectly, on local climatic conditions. There is greater resemblance in behaviour between plants in the same field than between plants in fields more widely separated. There was no resemblance between minor fluctuations in localities widely apart, though certain wide-spread climatic conditions may affect the general shape of the flowering curve similarly in different localities. [*Min. Agri. Egypt, Techn. and Sci. Ser. Bull.* 65, 1927, 40 pp., 31 plates. M. A. BAILEY and T. TROUGHT.]

Development of Pima and Acala Cotton Plants.

A study of Pima Egyptian cotton in comparison with Acala is described. The data given refer principally to the development of the fruiting parts of the plants in relation to their positions on the fruiting branches. The developmental periods and the abscission of the buds, flowers, and bolls have been found to differ with different positions on the fruiting branches. Differences between the two varieties of cotton, as shown by the data, indicate the possibility of determining many points relating to cultural practices and to the comparative value of varieties under these practices. [*U. S. Dept. Agri. Bull.* 1365, 27 pp. H. F. Loomis.]

Heritable Variations in Pima Cotton.

Evidence is presented of the occurrence of heritable variations in Pima cotton which is probably the most uniform variety of cotton grown on an extensive scale. Comparison of a progeny grown from seed of the parent individual of the variety with the present commercial stock proves that there has been significant improvement in the length and abundance of the fibre, as well as in the uniformity of these characters. Indications of the occurrence of heritable variations have been obtained in roguing fields of the Pima variety. The records of the breeding work with Pima cotton supply additional evidence of the occurrence of slight, heritable variations, none of which could be considered as outside the normal range of variation of this variety. They indicate, however, that something may be accomplished by selection in regard to characters of practical importance. A much more striking variation, characterised by the complete or nearly complete absence of the dark red spot near the base of the petal, associated with an increased percentage of 4-lock bolls, was found to be heritable in a high degree. The nature of this variation and the circumstances of its occurrence suggest the possibility that Upland cotton or Hindi cotton may have been involved in the remote ancestry of the Pima variety. The fact that heritable variations are found in this apparently uniform variety is thought to justify the continuance of selection and line breeding and the roguing of seed increase fields. [*Jour. Agri. Res.* 1921, **21,** 227-241. T. H. Kearney.]

Growth Studies of Cotton Plant.

Records of flowering dates, development of fruiting branches, squares and bolls, and maturation periods of bolls are given for Kasch, Mebane Latest Improved, Rowden, Truitt, Lone Star, Acala, and Kekchi cottons, grown at Greenville, Texas, in 1923-25. [*U. S. Dept. Agri. Circ.* 401 of 1927 ; pp. 17. H. C. McNamara, J. W. Hubbard and R. E. Beckett.]

Growth of Garo Hill Cotton.

The growth rates and sequence in development of the fruiting parts of Garo Hill or wool cotton (*Gossypium cernum*) were determined at Greenville, Texas,

by the methods which were used on the Egyptian and Upland types of cotton (A. 1925, 16 ; E. 1925, 103 ; and E. 1927, 45). Garo·Hill cotton is a native of India, but has bolls nearly as large as those of the Texas big-boll cottons. The interval between the appearance of successive fruiting branches on the main sta k is somewhat shorter in the Garo Hill cotton than in the other types, whilst the interval between successive squares on the branches is somewhat longer. The shedding of abortive bolls occurred within 3 to 5 days after flowering, whilst many abortive bolls of Lone Star were held from 6 to 8, and some from 9-11 days. The rate of growth of the buds and bolls was nearly the same as in the other types. The boll maturation period was somewhat longer than that of Lone Star, though the difference was slight and may not be significant. In the latter part of the season a lengthening of the maturation period of Garo Hill bolls was found, which also is in agreement with the behaviour of the Lone Star and Pima varieties. Garo Hill bolls which were set early in August had a period 10 to 12 days shorter than bolls set in September. [*Jour. Agri. Res.*, 1927, 35, 97-106. R. E. BECKETT.]

Personal Notes, Appointments and Transfers, Meetings and Conferences, etc.

THE New Year's Honours List contains the following names which will be of interest to the Agricultural Department :—

Rao Bahadur,	MR. D. ANANDA RAO, Deputy Director of Agriculture, Madras.
	RAO SAHIB T. S. VENKATRAMAN, Sugarcane Expert, Imperial Cane-Breeding Station, Coimbatore.
Khan Sahib.	MR. N. K. VACHA, Deputy Superintendent, Civil Veterinary Department, Baluchistan.
Rai Sahib,	MR. D. K. MUKERJEE, Civil Veterinary Officer, Baghdad, Iraq.
Rao Sahib,	DR. N. KUNJAN PILLAI, Director of Agriculture and Fisheries, Travancore.
	MR. G K. KELKAR, Extra Assistant Director of Agriculture, Central Provinces.
Ahmudan-gaung—Tazeik-ya Min,	U. PE, Deputy Superintendent, Civil Veterinary Department, Burma.

MR. M. I. RAHIM, I.C.S., has been confirmed in his appointment as Under Secretary to the Government of India in the Department of Education, Health and Lands.

MR. E. A. R. EUSTACE, I.C.S., has been appointed temporarily as Additional Under Secretary to the Government of India in the Department of Education, Health and Lands.

MR. F. J. WARTH, M.Sc., Physiological Chemist, Imperial Institute of Animal Husbandry and Dairying, Bangalore, has been granted leave for eight months from 15th March, 1928. Mr. A. V. Iyer will be in charge of the Section during Mr. Warth's absence.

MR. M. CARBERY, M.A., B.Sc., D.S.O., M.C., resumed charge of his duties as Agricultural Chemist to the Government of Bengal on the afternoon of the 6th December, 1927, on the expiry of his leave.

RAI SAHIB DIBAKAR DE, G.B.V.C., F.R.H.S., resumed charge of his duties as Assistant Principal, Bengal Veterinary College, on the afternoon of the 2nd November, 1927, on the expiry of his leave.

MR. D. R. SETHI, M.A., B.Sc., Deputy Director of Agriculture, Bihar and Orissa, has been transferred from the Orissa Circle to the South-West Bihar Circle with headquarters at Gaya.

MR. MUHAMMAD ISMAIL MALIK, B.Sc., M.R.C.V.S., has been appointed temporarily as a special officer in the Civil and Veterinary Department, Bihar and Orissa, for one year more, and is attached to the office of the Director of the Civil Veterinary Department at Patna.

ON return from leave Mr. D. Milne, B.Sc. (Agri.), C.I.E., resumed charge of his duties as Director of Agriculture, Punjab, with effect from the afternoon of the 28th December, 1927.

On reversion from his officiating appointment as Director of Agriculture, Punjab, *vice* Mr. D. Milne, Mr. H. R. Stewart has been appointed Assistant Director of Agriculture, Punjab.

Mr. Satya Dev Loomba, B.Sc. (Agri.), has been appointed Second Fruit Specialist to the Government of the Punjab on probation for two years.

Mr. Bajra Sain Sawhney, B.A., has been appointed Botanist for Millets to the Government of the Punjab on probation for two years.

Mr. Ram Battan Gulati, M.R.C.V.S., has been appointed officer-under-training in the Civil Veterinary Department, Punjab, on probation for two years.

Mr. W. M. Clark, M.B.E., B.Sc., Professor of Agriculture, Agricultural College, Mandalay, has been granted by the High Commissioner for India an extension of leave for six months.

Captain W. H. Priston, F.R.C.V.S., Civil Veterinary Department, Agra Circle, United Provinces, has been granted leave for ten months from 1st December, 1927.

The Woodhouse Memorial Prize for 1927 has been awarded to Mr. Badri Narayan Sinha, M.Sc., Research Scholar, Lucknow University, for a thesis on "The Origin" and Evolution of Archegonium.

REVIEW

Animal Nutrition and Veterinary Dietetics.—By R. G. Linton, M.R.C.V.S., Professor of Hygiene at the Royal (Dick) Veterinary College. Pp. 399. (Edinburgh: W. Green & Son.)

Those of us who are interested in the feeding of live stock have noticed the great advance that has been made in Britain in what may be called the scientific method of rationing. Within the last few years we have seen the old wasteful (and sometimes harmful) "rule of thumb" method being supplanted by reasoned and logical feeding. The writer was surprised when at Home in 1926 to find how many stock-owners had begun to adopt the new method and also how many of them were anxious for advice regarding food values more especially in their relationship to milk production. To these seekers after knowledge Professor Linton's book will be a boon. The language in which it is written is so couched that whereas the Veterinary Surgeon and the agriculturist can be convinced as to the scientific basis on which the findings are created, the stock-owner can also glean valuable truths to guide him in the nutrition of his animals.

To the "feeding of animals" the author has devoted 141 pages and each of these merits close attention and careful and repeated reading; Professor Linton has steered a sane course between the two schools of "no roots" and "roots in plenty" led by Boutflour on the one hand and Bond on the other. This discreet steering adds value to the book in that it shows that as we peruse this work we are in the hands of a navigator who will not allow himself to be deceived by possible mirages but will bring our ideas into the harbour of logical sequence by his daily observations.

To suggest improvements in this excellent work is difficult but one may be venturous enough to mention two points. In a second edition the description of the proteins (pages 14-21) might possibly be simplified and again on page 216 the author does not explain fully Rubners law or rather his explanation of it is hard to follow.

This book should be in the hands of every veterinary surgeon, agriculturist, student of agriculture or veterinary science and especially should it be read and reread and then read again by every one who desires to see that the best value is attained for his stock from the food he can supply to them.

The work of the publishers and printers is well done and the book is indexed in a complete manner. [R. F. S.]

NEW BOOKS.

On Agriculture and Allied Subjects.

Indian Agriculture, by Albert Howard, C.I.E., M.A., and Gabrielle L. C. Howard, M.A. (India of To-day Series, Vol. VIII), with 6 illustrations. Oxford University Press. Price, Rs. 2-8.

Economics of Agricultural Progress (with reference to conditions in the Deccan), by B. G. Sapre, M.A. (Printed at the Tutorial Press, 211-A, Girgaum Back Road, Bombay, and Published by B. G. Sapre, Willingdon College, Sangli.) Price, Rs. 2-8.

The Ant (with 43 illustrations), by Edward Step, F.L.S. (London : Hutchinson & Co., Paternoster Road.) Price, 7/6 nett.

Modern Bee-keeping, by Herbert Mace, F.E.S. (Printed by Wyman & Sons, Ltd., London, Reading and Fakenham.) Price, 5 nett.

Development of Irrigation in the Punjab, by Sohan Lal, B.A., B.T., F.R.G.S., Lecturer in Geography, Central Training College, Lahore. Arorbans Press, Anarkali, Lahore.

The Principles and Practical Considerations involved in Tea Manuring, by Dr. W. S. Shaw, Ph.D., M.Sc., A.I.C., Tea Scientific Officer, U. P. A. S. I.

The following publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Memoirs.

Studies in Khandesh Cotton, Part I, by S. H. Prayag, M.Ag. (Botanical Series, Vol. XV, No. 1.) Price, Re. 1-4 or 2*s*. 3*d*.

Bulletin.

The Mechanical Analysis of Tropical Soils, by J. Charlton, M.Sc., F.I.C. (Pusa Bulletin No. 172.) Price, As. 3 or 4*d*.

PLATE XV.

C. W. WILSON, M.R.C.V.S., I.V.S.

ORIGINAL ARTICLES

CHARLES WATERHOUSE WILSON, M.R.C.V.S., I.V.S.

AN APPRECIATION.

It is with regret that we learn that C. W. Wilson of the Indian Veterinary Service has proceeded on long leave pending retirement from the service. He was born on 5th December, 1874, at Coleshill House, Great Berkhampstead, Herts,—the son of the late Mr. William Wilson, the well known veterinary surgeon of that place and one time Vice-President of the Royal College of Veterinary Surgeons. He was educated at Berkhampstead school and at the Royal Veterinary College, Camden Town, which he entered in 1896 and from which he qualified as Member of the Royal College of Veterinary Surgeons in 1900, after a distinguished career at college having obtained honours throughout the course. On qualifying he responded to the call issued by the War Office for veterinary officers to serve with the Army in South Africa and immediately proceeded to the Front. He was awarded the King's Medal with five clasps. On his return to England he was selected for appointment to the Indian Veterinary Service, which he joined in April 1906, being posted to the Hissar Cattle Farm for training under Major Farmer. He was transferred to the United Provinces as 2nd Superintendent of that province in 1908 and continued to serve there until he was transferred to the Central Provinces as Superintendent, Civil Veterinary Department, in 1916. He was appointed Veterinary Adviser to the Government of the Central Provinces in 1921 which appointment he held until he left India on February 25th, 1928. He had organising and administrative abilities well above the average, and the way in which he administered and developed the sphere of usefulness of the departments of which he was in charge met with universal approval. He was a fine linguist and possessed an accurate and fluent knowledge of the vernaculars of the provinces in which he served. He was a regular examiner at the Bengal Veterinary College and elsewhere and was distinguished for his careful and patient examination of students coming before him for their oral examination. In private life he was popular with all he came in contact. He was a musician of a no mean order and devoted himself for many years to the training of the choir at the Nagpur Cathedral which he brought to a state of excellence which it will be hard to maintain without his constant care. He leaves India carrying with him the good wishes of his many friends.

K. H.

DAVID ALEXANDER DONALD AITCHISON, M.R.C.V.S., M.P.S., I.V.S.

AN APPRECIATION.

BORN on 8th January 1873, the son of Captain Aitchison of the Mercantile Marine and of Solway Bank, Dumfriesshire, coming of a stock which had been engaged in agriculture or as graziers for generations and being bred among the hills and moors of Southern Scotland, he naturally developed in early youth a strong bent towards pursuits connected with live stock and the sports of the field. He was educated privately and entered upon a business career in Coventry, but the life did not appeal to him and he found self-expression in the study of problems connected with stock breeding and animal husbandry. He eventually entered the Royal Veterinary College, London, in October 1895 and successfully passed the first two years of the course but was then struck down by serious illness which necessitated his leaving college for a time. He rejoined, however, after the lapse of a year and, completing his course, qualified as a Member of the Royal College of Veterinary Surgeons in July 1900. At that time the South African war was in progress and he immediately offered his services as a veterinary officer for service at the front where he served with distinction until the end of the campaign, receiving the Queen's and King's medals with three clasps. On the termination of hostilities he remained in South Africa to assist in demobilisation and in the suppression of the numerous outbreaks of contagious disease among live stock which ensued. He left South Africa in 1905 after having served there for 5 years.

He joined the Indian Veterinary Service in 1906 and was posted to the Madras Presidency immediately where he served his probation under Colonel Gunn and succeeded him as Principal of the Madras Veterinary College in 1909, a post which he held until 1925 when he became Veterinary Adviser to the Government of Madras.

The greater part of the present cadre of the Madras Civil Veterinary Department was trained by him and during the twenty-two years of his service he has been the teacher, trainer, preceptor and in short father of the present department, and its high state of efficiency is a living monument to his life's work in the Presidency of Madras. During his tenure of office at the college, vast improvements were made; the college buildings and the hostel were enlarged, the library and post-graduate rooms added, a fine laboratory erected and advanced courses of study in Pathology and Bacteriology introduced for graduates.

In private life Aitchison, or " Aitch " as he was familiarly called, was a genial, cheery companion, a fine shot, a keen fisherman and an all round sportsman. He

D. A. D. AITCHISON, M.R.C.V.S., M.P.S., I.V.S.

was an enthusiastic volunteer, serving for many years in the Southern Provinces Mounted Rifles and attending the Delhi Durbar of 1911 with that corps and being awarded the Durbar Medal.

On the outbreak of the Great War when the Emden was scouring the Bay of Bengal and the Indian Ocean he accompanied as Veterinary Officer the shipment of horses, presented by the Madras War Fund, from Madras to Southampton, for which service his name was mentioned in despatches. On his retirement which takes place in May of this year (1928), he will leave in India a host of friends, both British and Indian, who will continue to remember him with feelings of affection and regard.

"Vale"

K. H.

TEA IN NORTH-EAST INDIA, II.

BY

P. H. CARPENTER, F.I.C., F.C.S.,
Chief Scientific Officer, Indian Tea Association.

(Continued from Vol. XXIII, Pt. I.)

THE CLIMATE.

THE predominating factor which has made Assam such a successful tea-growing country is its climate. The tea bush grows on practically any type of soil from the peats or *bheels* of the Surma Valley and the heavy clays of the Dooars to the light, poor sands found near the Brahmaputra, but, in order that it shall thrive, it must have a warm, moist climate with no long droughts. This first necessity was recognized many years ago and the following extract, taken from the Tea Cyclopædia published in 1881, is of interest in this connection.

" Tea, it may be premised, will grow almost anywhere, but not very many climates will enable it to pay.

" To describe the best climate in two words, we point confidently to Eastern Bengal; indeed, the judgment of a considerable portion of the Indian public interested in tea has long since pronounced the same decision. A hot, moist climate, where the thermometer in the shade never exceeds 95° F.; never falls below 55° F.; where the rainfall yearly aggregates 100 to 130 inches; where there is never any long drought, but where rain falls at reasonable intervals all the year round; where heavy dews are frequent; where morning fogs are not uncommon; where the sun shines hot in an atmosphere perfectly free from dust; where at no season can a breath of hot wind be felt; where light, penetrating rain is more common than furious downpours; where the effect of the entire climate is essentially enervating to man, and takes much out of him; these are the conditions that constitute, in our opinion, good climate for tea, and where it is wise, if wise anywhere, t make tea gardens. Fever and tea go together. It may be a painful fact for tea planters, but it is no less true. No highly successful tea district can ever be a healthy one."

Eastern Bengal probably refers to Cachar, for the temperatures recorded in the Assam Valley fall considerably below 55° F. The statement that fever and tea go together fortunately no longer holds good.

In order to understand the climate of North-East India and to realize how conditions in that area differ from those in Ceylon and South India, the other two big British tea areas, it is necessary to have some idea of the monsoon changes.

Broadly speaking, there are two sets of winds blowing steadily across the earth, the trades and the anti-trades. The trade-winds blow from the north and south to the Equator, but, owing to the revolution of the earth, the general direction is from the north-east and south-west. In the temperate zones the complements of these winds, the anti-trades, are met blowing from a south-westerly direction in the northern and a north-easterly direction in the southern hemisphere. Between these two sets of winds are two belts of calm where are found the deserts and Sargasso seas.

But for the land mass of Central Asia peninsula portion of India would be in the course of a steady trade wind from the north-east, and Northern India would be included in the chain of deserts formed by Sahara, Arabia, Persia and the Thar desert. As it is, the land mass of Asia warms up in the summer months and there follows a general flow of air from the southern latitudes to take the place of the air rising from the Asiatic plateau. Eventually, this air flow becomes strong enough to overcome the north-east trade wind and then the south-west monsoon begins to blow. The strength of the monsoon varies with each season, and although the ultimate cause of this variation has not been decided, it depends in part, at any rate, on the oscillations of the two winds which are pitted against each other.

West of Ceylon the monsoon current splits into two main components, one running up the east coast of Africa and the other round the Bay of Bengal.

The current moving up the African Coast sheds copious rainfall on the Abyssinian plateau which floods the Nile and enables the Egyptian crops to flourish in a permanently cloudless sky. After meeting the Abyssinian plateau, the current makes an eastward turn passing Cape Gardafui and the island of Socotra and, having lost practically all its northerly component, reaches Bombay from almost due west. The rainfall at Bombay is 150 inches, but inland it decreases quickly and Poona has an average of under 30 inches, although further from the coast there is an increase again. Arabia, Persia and Sind thus miss the monsoon and Karachi has a rainfall of under 10 inches.

The Bengal current is weaker than the African one. During its movement round the Bay, it serves the southern part of Burma and then comes to Bengal. Both currents are influenced by a depression which occurs in part of Sind and Rajputana.

Towards the end of the season, the Bengal current is caught up in cyclones which whirl it across India and the rainfall brought in this manner has a great influence on the winter crops.

Before the summer is finished, the attraction towards Central Asia begins to weaken, and by the autumn the air flow definitely begins to turn southward and the cloud canopy is withdrawn from Northern India. The north-east trade winds previously extinguished by the monsoon, are now reinforced by cold, dry winds blowing from the desert of Tibet which warm up as they cross the Bay of Bengal and pick up moisture to be deposited later on the southern half of Madras.

From the above brief account of the general air movements over India, it will be understood that Assam and the north-east corner are out of the track of the monsoon, yet on account of the general air drift towards the Tibetan plateau, there is a steady flow of moist air into this area. Furthermore, the Himalayan barrier and the funnel shape of the Surma and Brahmaputra valleys ensure that clouds, when they once enter the country, are shepherded round the hills till they are deposited as rain. Because of this, Assam is one of the permanently green provinces in a continent where conditions are, on the whole, arid.

It will also be seen that the western side of Ceylon and South India are served mainly by the south-west monsoon which a week or two later arrives, by a different route, in Assam. The eastern side of Ceylon and South India are served mainly by the north-east monsoon which blows dry over North-East India before reaching the Bay of Bengal.

The rainfall tables below illustrate the variation in rainfall in the three districts. The first table shows the rainfall in typical areas of Ceylon.

Average rainfall in Ceylon.

—	Colombo	Kandy	Nuwara Eliya	Badulla
	in.	in.	in.	in.
January[1]	3·36	5·22	5·65	9·71
February	1·84	2·23	2·03	3·02
March	4·30	3·86	5·11	4·34
April	9·67	6·78	5·66	7·46
May	10·73	5·43	6·64	4·45
June	7·20	9·64	12·85	2·29
July	4·48	7·50	12·07	1·99
August	3·14	5·69	7·91	3·22
September	4·73	5·93	8·29	3·37
October	13·44	11·80	11·13	9·88
November	11·59	10·57	9·00	10·45
December	5·11	9·12	8·57	12·43
TOTAL	79·59	83·77	93·12	72·01

At Colombo both monsoons are distinctly marked with dry periods between them. Kandy, occupying a central position in the island and not cut off on either side by high mountain, gets a more evenly distributed rainfall in addition to generous precipitations from both monsoons. Nuwara Eliya is similarly treated. Badulla, in Uva, is on the east side of the rain divide and receives most of its rain from the north-east monsoon.

In South India, the extremes of rainfall are shown by Madras on the Coromandel Coast, facing the Bay of Bengal, and at Cannanore on the Malabar Coast, facing the Arabian Sea. Towards the west coast are the tea districts. The Nilgiri District is the one farthest from the sea and the Anamalais and Travancore face the weather. These points are illustrated in the table below :—

Average rainfall in South India.

	Madras	Cannanore	Nilgiri	Anamalais	Travancore
	in.	in.	in.	in.	in.
January	1·14	0·25	2·38	0·40	0·41
February	0·30	0·26	2·32	0·12	1·47
March	0·34	0·18	1·94	0·21	0·44
April	0·63	2·15	4·12	3·48	2·52
May	1·84	7·78	6·00	3·99	11·77
June	1·97	38·22	4·08	28·56	48·67
July	3·84	35·07	4·74	83·18	74·33
August	4·54	18·83	4·33	23·70	40·47
September	4·86	8·63	6·63	17·34	26·47
October	11·15	7·95	14·35	8·17	19·69
November	13·61	3·67	10·16	3·35	23·85
December	5·35	0·61	4·30	0·33	0·51
TOTAL	49·57	123·50	66·35	172·83	250·31

In Assam, the rainfall varies over a wide range. At Cherrapunji, one of the wettest spots on earth, it averages 381 inches with a maximum record of 905 inches.

In Silchar it is 122 inches, in North Lakhimpur it is more than 160 inches and at Dibrugarh 122 inches. In the rain shadows of the Mikir Hills in the Golaghat District, it drops to about 50 inches.

At Tocklai the average for past nine years is 82 inches, although there has been a wide variation on either side of this value. From 1917 to 1926 the values recorded have been 97, 75, 68, 82, 74, 101, 66, 86 and 75 inches. The table below shows the rainfall at various stations in North-East India.

Average rainfall in North-East India.

	Assam Valley (Tocklai)	Surma Valley (Silchar)	Dooars (Sylee)
	in.	in.	in.
January	0·95	0·64	0·47
February	1·35	2·32	0·74
March	3·59	7·99	1·12
April	7·89	13·56	3·99
May	9·66	15·72	11·09
June	12·43	20·39	33·43
July	17·04	19·98	44·5
August	13·01	18·69	28·21
September	10·11	13·95	28·07
October	4·47	6·40	7·49
November	0·92	1·31	0·98
December	0·37	0·54	0·19
TOTAL	81·79	121·43	164·48

Although rainfall is the chief factor in determining the suitability or otherwise of a district in India for tea, the distribution of the rainfall is an important factor. In addition to this, humidity plays a dominant part. In Northern India generally, the year may be divided into three seasons, the cold dry season lasting from November to February, the hot dry season lasting from March to May, and the hot, wet

season of the monsoon lasting from June to October. The tea bush is an evergreen, designed by nature to grow in a warm, humid climate ; and if the hot dry season is well marked as it generally is in Northern India, then tea will not flourish. In the outlying districts of North-East India like South Sylhet and the southern part of the Jalpaiguri district, although the rainfall in the spring compares favourably or is even greater than that in the Brahmaputra Valley, the humidity is low and the bushes stop flushing.

The table below shows the rainfall at Habiganj in South Sylhet where the tea goes *banjhi* in the spring. At the town of Jalpaiguri, which is about 40 miles south of the Himalayan foot-hills, the tea acts similarly and is sometimes pruned in the spring. At Ranchi, in Orissa, the early drought is so severe that the bushes are sometimes completely defoliated. At Dehra Dun the same thing happens.

Station	Habiganj (Sylhet)	Jalpaiguri	Ranchi	Dehra Dun
	in.	in.	in.	in.
January	0·45	0·30	0·63	2·19
February	1·24	0·66	1·24	2·49
March	4·53	1·36	1·10	1·46
April	9·08	3·73	0·80	0·78
May	15·42	11·07	2·33	1·57
June	19·74	23·73	9·00	8·29
July	15·82	31·28	14·46	24·33
August	14·23	25·04	13·61	25·68
September	11·78	19·94	8·23	9·30
October	5·90	4·90	2·79	0·29
November	0·83	0·20	0·37	0·92
December	0·27	0·11	0·16	0·67
TOTAL	99·29	122·32	54·72	77·97

In Assam and the Dooars the advance of the monsoon is marked by a rise in temperature and humidity. During the cold weather a difference as great as 30° F. is often registered between the maximum and minimum temperatures, but after

the monsoon has broken, the difference is usually about 10° F. The table below shows the maximum and minimum temperatures of typical stations.

	Silchar (Surma Valley)		Tocklai (Assam Valley)		Jalpaiguri		Darjeeling	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
January . . .	78	52	70	50	72	51	47	35
February . . .	81	56	73	53	77	53	48	36
March . . .	86	63	79	60	85	60	51	42
April . . .	89	69	83	67	90	68	62	49
May . . .	89	73	86	72	88	72	64	53
June . . .	89	76	89	76	88	75	65	56
July . . .	90	77	90	78	88	77	66	58
August . . .	90	77	89	78	88	77	66	57
September . .	90	76	88	76	87	75	64	56
October . . .	89	72	85	71	86	70	61	50
November . .	85	64	78	60	81	61	54	42
December . .	80	55	72	51	75	53	49	37

In Ceylon and South India the seasonal differences are very small and the mean temperature shows practically no change. At Ratnapura in the low-lying tea district of Ceylon, the annual mean is 80° F., at Kandy (1,654 feet) it is 74° F., at Nuwara Eliya (6,188 feet) it is 59° F. and at Badulla (2,225 feet), in Uva, it is 74° F. At Kotagiri in the Nilgiri district of South India the annual mean is 73° F.

The absolute humidity as measured at Tocklai shows a value of about 0·4 to 0·5 in. mercury in January. In March or April it begins to rise and reaches a value varying from 0·6 to 0·8 inch. With the break of the monsoon there is another rise to about 0·90 inch at which figure it is roughly maintained till September or October when it steadily falls, till in December it is back to 0·4 to 0·5 inch. Humidity controls our tea crop.

The wind direction is either north-east whence it blows cold and dry, or south-west from which direction it blows warm and moist. During the monsoon there is a general air drift from the south-west. The early months of the year are most windy, and during March, April and May hurricanes often blow, some-

times with hail. The latter contingency is a real danger, for a hail storm may well strip a whole area of tea. Most gardens in districts liable to hail insure against such damage.

Only 3 years' wind records are available for Tocklai and the average of these is given below and illustrates roughly the change in rate of air drift.

Daily wind mileage at Tocklai.

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Average 3 years . . .	26	40	55	74	42	43	43	41	35	25	20	16

The amount of sunshine is an important factor influencing, as it does to some extent, the tannin content of the leaf and also having an effect on the reproduction and attack of certain fungus diseases.

Sunshine is, in part, a complement to rainfall and varies to some extent inversely as the latter. The average sunshine at Tocklai recorded during the past 9 years is as follows :—

Average daily sunshine in hours at Tocklai.

Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
5·3	5·7	5·7	4·9	4·7	4·2	4·0	4·4	3·9	5·8	5·6	5·2

The decrease in sunshine with the coming of the monsoon is well marked. July is the wettest month and August on the average wetter than September. At times, however, long sunny spells are experienced in August and these periods raise the sunshine average.

In the Dooars the sunshine average generally seems to be smaller than that in Assam. Only two years' records over the mid season are available and these show a wide variation. The table below shows the values for 1925 and 1926.

Hours of sunshine per mensem at Sylee (Dooars).

	April	May	June	July	August	September
1925	118	101	124	94	96	86
1926	180	147	91	68	127	170

Much less sunshine is recorded in the Dooars during the monsoon than in Assam as the table below shows.

Hours of sunshine per mensem at Tocklai.

	April	May	June	July	August	September
1925	105	102	156	158	136	117
1926	177	170	131	112	149	124

A sunny season, especially a sunny spring in the Dooars, is considered to be associated with light tea mosquito (*Helopeltis*) attack. No sunshine records other than those quoted above are available for the Dooars, but it seems probable that what is regarded as a sunny season in the Dooars may show a record of hours of sunshine no greater than is the general average in Assam. In Sylhet, where, from experience only, it is assumed that the hours of sunshine approach those in Assam, a sunny start to the year is thought by many to mean a heavy mosquito attack later. A sunny start means a severe drought usually, and a serious weakening of the bushes.

Until more records are available, little progress will be made in correlating pest and blight attack and sunshine.

As previously mentioned, humidity is the main factor controlling the tea crop. In the Brahmaputra Valley the bushes are tipped in March or April after the spring flush. The first real flush comes in May and the second in June. The big months are July, August, September, and during these months 50—60 per cent. of the crop is gathered. The half season occurs about the middle of August. October is a good month varying greatly, and November gives one or two good pluckings if the rains hold good. From December till the spring tipping, the bushes are not plucked. Our heavy flushing period corresponds with a combination of high temperatures and humidity (both relative and absolute) which is characteristic of monsoon conditions.

In Ceylon, as in India, the bushes begin to flush, without the stimulation due to plucking, with the spring rains. The heaviest flushing months all over the Ceylon tea districts both in the south-west and the north-east monsoon areas are March, April and May. During the first six months of the year many estates make two-thirds of their crop. In June, July and August, during which time the monsoon blows hard and the rain falls in torrents, the crop is poor. After August the crop

increases to a second maximum in November. December, January and February are again poor months in the south-west area although in Uva, November, December and January are good months, owing to the north-east monsoon rain.

In South India plucking generally continues throughout the year although during the height of the monsoon the bushes may close. There are two big flushing periods, the first being April-May when about 25 per cent. of the total crop is made, and the second, September to December, when 35—40 per cent. of the crop is made. Great variation in cropping intensity is, however, shown in different districts.

(To be continued.)

THE INDIAN SUGAR BOWL AND AGRICULTURAL RESEARCH IN CONNECTION THEREWITH.*

BY

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I. INTRODUCTION.

GENTLEMEN,

ALLOW me first to extend to you a very sincere welcome to the Agricultural Section of this Congress. This section of the Congress was first inaugurated at its third session at Lucknow in the year 1916 and ever since it has been steadily growing in every respect. This is but as it should be because of the great importance of this staple industry to our country.

There are certain special circumstances associated with the current Agricultural Section of this Congress. The Royal Commission on Agriculture in India is still in our midst and this day only about a thousand miles from this meeting. Secondly, this Congress has had the rather unique privilege—I take it for the first time in its history—of having His Excellency our Agricultural Viceroy as one of its patrons. A third happy circumstance which, however, has been in operation for some time past is the steadily increasing interest which our legislatures and the public are taking in the development of agriculture and the various problems connected with it. The Reforms have directly contributed to this happy result.

Under these circumstances I cannot help feeling that it would have been more appropriate if an abler person than myself had filled this chair. There is, however, one excuse for me and one consolation for you ; on such occasions the Chair possesses a value of its own apart from the individual occupying it, a value derived from its previous occupants and the other traditions associated with it.

Going through the addresses of the previous presidents, I notice that the subjects chosen for the address are either on general agriculture or on the subject in which the occupant of the chair might have specialised. I have taken as my subject, " The Indian Sugar Bowl " and trust to its contents to render the subject attractive to this audience, if my method of handling it falls short of your expectations.

II. INDIA—THE ORIGINAL HOME OF THE SUGARCANE.

It is now widely accepted that India was probably the original home of the sugarcane and that the knowledge of the cane and the manufacture of an edible product

* Presidential Address at the Section of Agriculture, Fifteenth Indian Science Congress, Calcutta, (1928).

from it was known in this country from very ancient times. In the early days—before the beginning of the Christian era and for some little time after it—the Indian production of sugar represented that of the world and the only one in it.

It will take some time to detail here the various data on which the antiquity of sugarcane in India is based. I shall, therefore, content myself with mentioning the more important of them :—

(i) Mention of the cane and its products is found in the earliest literature of our country and no other. The elaborate descriptions of Greek and Roman dinners do not contain any reference to sugar ; the elaborateness of the descriptions renders it unlikely that the omission was accidental.

(ii) The sugarcane was so well known during the time of the Sakyas that they adopted it as their emblem. There is a reference to the plant in the Institutes of Manu, thus taking us back to over a thousand years before the Christian era.

(iii) Authenticated records are available to show that the cane migrated to other countries either from India or from countries which originally would have received it from India.

(iv) Some of the indigenous canes, cultivated over large tracts in this country to-day, are the nearest approaches to the probable wild progenitor of the cane. These are also some of the hardiest in the world.

III. Its migration to other countries.

China must have known of the sugarcane and its products very early—as it is repeatedly mentioned as tribute to the Emperor of China from the Indian border provinces. It is recorded that in 1270 A.D., many sugar factories were flourishing in South China and sugar was available there at cheap prices.

It is more than probable that Java—which to-day supplies the bulk of the Indian needs in white sugar—also obtained the sugarcane either direct from India or through China. The trend of recent discoveries would render the former alternative more likely. The cane has been in cultivation in this island from as early as at least 424 A.D.

The wars and conquests of the Byzantines, the Moors and the Crusaders took the cane to Egypt, Spain, the Islands in the Mediterranean and the borders of that sea on the European as well as on the African coasts. In the beginning of the sixteenth century, Venice was a very important port dealing in sugar.

The discovery of the New World and the subsequent colonization of that vast continent by the Spanish, the Portuguese, the Dutch, the English and the French brought fresh areas under cane and greatly contributed to adding to the contents of the world's sugar bowl. This great extension of area brought this important article of food within the reach of the ordinary consumer. In the olden days, when

the world area under the crop was limited, the article was so costly as to allow its use only as a luxury or in medicine. "Like an apothecary without sugar" is an ancient proverb still current in Spain.

The study of the spread and development of the sugar industry in various parts of the world is very fascinating, as it is very closely associated with political and other changes. "Blood and tears, piracy and bitter despair, as also ambition, invention and great adventure are inextricably woven with the history of sugar in the world." By an irony of fate this sweet product is intimately associated with some of the darker sides of human nature, with wars and slavery. The cultivation of the cane demands the employment of considerable and rather exacting labour; and sugar plantations in the earlier days were some of the places where slaves were freely used to the advantage of the industry. In fact, the abolition of slavery over the greater part of the world between the years 1825 and 1850 disorganized the industry in many places; and it is sad to contemplate that cane cultivation was at one time an inducement for continuing this blot on humanity.

IV. The birth of a rival—the sugar beet.

Up to the beginning of the nineteenth century the sugarcane was practically the master in the field as the one plant from which sugar could be obtained. At this period a formidable rival appeared in the shape of the sugar beet. The beet sugar industry was born under the boom of French and German guns and, during its earliest days, was largely nursed by Fredrick William of Prussia and the Emperor Napoleon. It was a time when the two then most powerful nations of the world sought to give battle to each other not only on land and sea, but by each trying to starve the other in the matter of supplies. The beet root was one of the weapons with which Napoleon sought to support himself against England.

The free and large imports of sugar into Europe from the Colonies had developed in the mother countries a craving for this important and agreeable article of food. When England effectively prevented sugar reaching France, the great Napoleon smarted under it and engaged a band of scientists to discover an alternative for the sugarcane. He caused various plants growing in France and other European countries to be examined for the possibility of obtaining sugar from them. The birth of the beet sugar industry in Europe was one of the direct results of this gigantic endeavour.

With his immense powers as Emperor, the beet sugar industry received so much patronage and encouragement at his hands that it had to pass through severe crisis when all this patronage became suddenly unavailable with the downfall of Napoleon. The industry was very much like a spoilt child, petted and fondled amidst luxurious conditions, suddenly thrown into the ordinary conditions of life. The beet sugar industry soon recovered itself, however, with the application of science and industry and is now a serious rival to the sugarcane. On the whole, the sugar beet thrives

in regions where the cane is not at its best. This has tended to greatly limit the otherwise very severe competition which would have come into being between these two great rival sources of sugar. As it is, the competition is keen enough and it is difficult to foresee at present what other rivals await us in the future. Will the world one day suddenly wake up to find proved the possibility of the manufacture of synthetic sugar on a commercial basis ?

V. The Indian sugar bowl—its contents and composition.

After these general observations on the world sugar bowl through the ages, let us pass on to a consideration of the Indian sugar bowl as it is to day, its contents and composition, sources of supply and, what might be termed, the economics of it.

Sugarcane and its products are consumed in our land in quite a variety of ways. First and simplest is its consumption as a fruit. This method is pristine in its simplicity, involves no outlay on mills or machinery and has no foreign competition to contend with. For obvious reasons, it does not, however, lend itself to being adopted on an extensive scale. It is limited in scope and confined to only such individuals as are endowed with a good outfit of milling apparatus in the shape of strong and sound teeth.

Secondly, there is the rather crude product resulting from the boiling down of the juice in open pans and now largely carried on as a cottage industry. There is an endless variation in the quality and composition of this article ; but, where the process of manufacture is clean, the result is a wholesome and appetizing article of food, said to be richer in vitamine B than refined sugar.

The third product is what is generally known as "shakkar." This again is of two kinds, *viz.*, (1) a product very similar to *gur* but in the powder form, the clarification and removal of impurities being done a little better than in *gur* manufacture and (2) a more or less crystalline article which is recovered from a product called "rab" after considerable loss of sugar in the process.

The market for this commodity rests chiefly on sentiment and religious scruples which, however, are gradually wearing out. Its existence is increasingly threatened by the competing factory-made sugar. To my mind, its future is limited to conditions where it has the advantage of being run as a cottage industry.

Fourthly, there is the refined product as obtained through modern machinery in factories, of which there are a certain number in the country. So far these have largely been the result of foreign enterprise and are concentrated chiefly in Bihar. The number of such factories is altogether inadequate, as their total output in refined sugar is less than a seventh of our present consumption.

VI. Analysis of our consumption and its lessons.

It is both interesting and profitable to examine in detail our consumption of *gur* and sugar products during the year. Such an examination, besides enabling us

to form correct ideas about the relative importance of each of the products to the country, should indicate the directions in which improvements are both important and urgent.

To facilitate comparison I shall take the figures in rough and round numbers. The annual consumption of *gur* and sugar combined is roughly a little over three and a quarter million tons. Of this about 75 per cent. consists of *gur* and *desi* sugar. Of the remaining 25 per cent. about 3 to 4 per cent. is crystal sugar *home made* in more or less modern factories and refineries working in this country. The remainder, *i.e.*, between 21 to 22 per cent., has to be imported each year from outside, chiefly Java, at a total cost of about 15 crores of rupees. The lessons from the above analysis are obvious.

The bulk of the Indian consumption is in the form of *gur* and so all work directed towards increasing the quantity or improving the quality of *gur* made in the country either directly or indirectly are bound to be of immediate benefit to the Indian grower and consumer.

The *gur*, *gul*, *gud* or *jaggery* is a product rather characteristic of our land and enjoys a privileged market in the country partly from sentiment and partly because of the peculiar flavour associated with it. In the Indian bazaar this article is at times dearer than even the refined product, in terms of the crystal sugar contained in it. While the dumping of cheap white sugar into the country does often-times place it in a precarious position, it is likely to hold its own as a cottage industry for some considerable time to come. It enjoys a considerable amount of protection from the Indian sentiment in favour of it and heavy transport charges from the coast to the places of consumption. The two principal drawbacks in this product are (1) the difficulty of keeping it for long periods and (2) the wide variations in quality and composition.

The figures for the refined article show that its production inside the country is very small—less than one-seventh of the consumption—and an early increase in the supply of the home product would be necessary to make India self-contained in this important article of food and prevent the great drain to the country resulting from our heavy imports in this article. The urgency of the improvement will be better realised when it is remembered that with the advance of time the refined article shows an increasing tendency to replace the home made, but comparatively crude product, *gur* in the Indian kitchen.

VII. Present location of the Indian sugar bowl—outside the country and across wide seas.

From the foregoing it is clear that at present the Indian sugar bowl is not happily placed. In the matter of refined sugar our bowl is placed away from the country and across the wide seas; and every time we have to stretch our hands to reach to it. With the experience of the recent great war, the seriousness of the present

condition will be readily realised and there could be little doubt that it needs serious and urgent attention.

There is yet one other, rather startling, fact which renders our position particularly pitiable. Not only is it that the cane probably originated in India but even to this day we have in the country nearly half the world area under the crop—an area easily greater than that of any other single country in the world. That, in spite of this vast area, India has to import annually large quantities of white sugar from outside results from two causes. One is that the acre yield in this country is comparatively low, being less than one-third that of Cuba, one-sixth that of Java and one-seventh that of Hawaii in terms of sugar.[1] The second is that the factories in the country are few and have often to struggle with a poor class of cane equally disadvantageous to the grower and the manufacturer.

VIII. The problem and its remedies.

Glancing through the work that has been done on this crop in the past—and such work began largely with the founding of Agricultural Departments all over the country—one finds that until recently it was mainly directed to the solution of local problems. In one case it was perhaps the introduction of a new cane to secure increased yields or to fight out an existing disease, and, in another, improvement in methods of *gur* manufacture, either to prevent losses or to make the process more economical. Very valuable work has been done in these directions; but the fact remains that till recently no attempt was made to attack the Indian sugar problem as a whole and in all its bearings.

It was in the year 1911 and during the pre-reform days that an unofficial Indian Member of the Imperial Legislative Council of those days, the Honourable Pandit Madan Mohan Malaviya, drew prominent attention to the unhappy condition of the Indian sugar industry, a position which was steadily growing worse with the advance of time. The All-India Board of Agriculture paid marked attention to it in the year 1911 and subsequent years and made definite recommendations. This period really marks a new era in the history of the industry as with it begins the tackling of the problem as a whole and on all-India basis. The Indian Sugar Committee which followed in the year 1920 and the very careful and detailed recommendations made by that painstaking body greatly contributed to the clear elucidation of the difficult problems associated with the industry.

I have already mentioned that the Indian yields are very poor as compared with those of other countries. This is mainly due to two causes. One is the poor quality of cane grown over the bulk of the Indian area and the other is the considerable loss from the wasteful methods of manufacture adopted at present.

Improvements in methods of manufacture of *gur* and country sugar are very important, confer an immediate benefit on the people connected with the industry and have been receiving attention in all the provinces. But the problems

[1] Report of the Indian Sugar Committee, 1920, p. 7.

associated with it are often rather local in character. Not only the conditions but the requirements of the *gur* market vary widely from place to place.

In the matter of improving the type of cane grown, the first and obvious line of attack adopted in earlier years was that of importing improved types from a different locality or from a country overseas. It soon turned out, however, that such types were not useful over the bulk of the Indian cane area which is situated in sub-tropical regions.

The Indian canes, though comparatively poorer, possess certain very useful characters. They are very hardy and having been grown in the country for very long periods are eminently adapted to what are generally considered unfavourable conditions for cane.

The remedy was obvious. It consisted in trying to combine in a new cane or canes the superior qualities of the tropical types with the hardiness and growth characters of the indigenous kinds. The results have been eminently satisfactory as will be shown in the course of the address, and involved the breeding of new seedlings after rather complicated hybridization. As the work is rather new and possesses certain characteristic features, it would not be out of place here to review briefly the salient features of this work.

IX. Sugarcane breeding.

The breeding of sugarcane differs in certain essential respects from that of most other crops. For one thing the growing of plants from seed does not, with most others, offer any special difficulty. It is not so, however, with the cane. Certain varieties do not flower at all, others are infertile in one or both of the essential organs and the young seedlings are generally rather delicate in the early stages and need considerable care to nurse them to maturity. Secondly, in the cane the plants from seed do not resemble one another or either of the parents, even when precautions are taken agains chance hybridization in the field. Thirdly, the inheritance of characters in the cane has not yet been traced to any well defined laws, which places the breeding of canes in a class by itself. The cane-breeder is wholly unable to know beforehand what kind of seedlings to expect from a particular combination and, in the present state of knowledge, has largely to depend upon increasing the chances of obtaining the desired combination by growing a very large population. The number of seedlings raised each year at Coimbatore has often exceeded a hundred thousand and it is often a job, in the first instance, to grow and later to select from such a large number.

But conditions are, however, steadily improving. The technique of breeding which involves some research has been considerably simplified and rendered more reliable in recent years, the station at Coimbatore contributing to some extent in this good work. Secondly, though definite laws have not yet been established in connection with the inheritance of characters in the cane, data are rapidly accumulat-

ing as to the type of seedlings each variety may be expected to yield. All these are steadily introducing greater certainty in cane breeding operations, though it may yet be long, before almost mathematical accuracy like that now associated with the breeding of most other crops is available for sugarcane.

Every cloud, it is said, has a silver lining and the work of the cane-breeder is not without certain compensating advantages. When once the improved cane is secured, its further multiplication is a comparatively easy matter. The method of vegetative multiplication through cuttings—which is the method adopted in ordinary cultivation—ensures the reproduction of the superior qualities more or less intact in subsequent crops.

The breeding of canes at Coimbatore was started only in the year 1912 and this day as many as over 70,000 acres are under the improved Coimbatore canes. The Coimbatore canes give yields which are sometimes 100 to 160 per cent. superior to those of the indigenous varieties ; and a conservative estimate of the additional profit to growers has placed it over 79 lakhs of rupees during the season just passed.

By itself, it has to be admitted, this is not a big saving for a big country like India ; but even so it needs to be mentioned that it is over 140 times the annual recurring expenditure on the station. When it is realised that the total cane area in India is about $2\frac{3}{4}$ million acres, that these improved canes have only just started getting into cultivation, and that the 70,000 acres now grown with the improved canes represent less than three per cent. of the possible area, it would readily be conceded that the future possibilities are indeed great. Cane-breeding has conferred great benefits on more than one country in the sugar world and experience so far gained in India would indicate that, if anything, the benefits would be greater to this country. The data already to hand fully justify my stating that cane-breeding is going to be one of the most effective means for making India self-contained in the matter of sugar, if not for exporting it.

X. THE FACTORY INDUSTRY.

But the breeding of canes at Coimbatore is only the beginning of the problem. It is perhaps also the only right way of beginning it, because, without the right cane to grow in the field, it is both futile and risky to develop in other directions. It has also proved a very hopeful and auspicious beginning. In a very short period it has knocked the bottom out of the belief widely held that profitable cane crops could not be grown over the bulk of the Indian cane area because of its sub-tropical conditions. Over parts of Bihar it has shown that yields could be doubled over large areas with but little alterations in cultivation methods.

The fact appears to have been, not that the bulk of the Indian area could not grow profitable cane crops, but that so far science had not been diligently applied to the problem. The Indian canes have in them certain very useful characters—discovered and utilised by Java as early as the nineties of the last century—and

a rather complicated hybridization with the tropical canes, roping into the parentage certain wild grasses allied to the sugarcane, was needed to yield the improved types which would grow and flourish in the Indian cane area. The range of varieties available in our country is very large—much larger than in most others—and a continuous application of science is all that is needed to steadily augment our present low acre yields. Java, within the last sixty years, has shown the utility of the application of science to the industry. Her acre yields which in 1860 were only about 1½ tons are to-day well over 5 tons.

Now that the improved canes are available and would be so in increasing numbers in the future to suit the varying conditions of Continental India, it now remains to organize and improve in various directions the subsequent stages in the industry. The ideal before a breeder ought to be to evolve types suitable to any given set of conditions and cane-breeding should therefore be equally useful to the growers, whatever be the manufactured product in individual cases. The Coimbatore-bred canes have already proved this. They have benefited equally the small grower preparing *gur* as a cottage industry, the planter supplying canes to the modern factory and the factory itself.

These improved canes with their higher yields and other advantages are bound to bring up for solution other problems such as the need for a better system of manuring and cultivation, adjustments in factory operations and disease incidence, in the last of which breeding should again prove useful. Nature is loath to bestow a gift without some hard fighting.

The one immediate problem before the country is to make India self-contained in the matter of sugar; and so far as one is able to see at present, the founding of more factories in the country is the only solution. I have the authority of experts in the field, experts with plenty of experience of all the aspects of the sugar industry in other countries, to state that there is scope in the country for the founding of such factories. The problem is not without difficulties; but it has truly been said that difficulties exist only to be overcome.

The Imperial Department of Agriculture in India has taken in hand other phases of the problem besides cane-breeding. One such is the Sugar Bureau at Pusa which within the very short period of its existence, has already given a new lease of life to the white sugar industry in at least one province, *viz.*, Bihar.

XI. Sugar as food.

Before concluding this address there are one or two points to which I wish to draw particular attention. One is the increasing recognition of sugar as an agreeable and valuable food. As to its agreeableness no proof is needed. It is within the personal experience of all of us here. Its food value, however, is not so well known.

Food for human consumption may be broadly divided into two classes, *viz.*, maintenance foods and fuel or energy foods. Sugar belongs to the latter class and is

very valuable as such. In the recent Great War, it is said, look-outs on ships used to be specially rationed with sugar on stormy nights. Arctic explorers and mountain climbers like Sir Earnest Shackleton and Dr. Malory have testified to the value of sugar as an energiser. Sugar is the cheapest food for purchasing energy. An anna would buy 545 calories when laid out on sugar as against 395 for bread, and 180 for milk. It has been claimed that a very minute variation in the glucose of the blood may make the difference between cowardice and courage, may determine if a man is to be shot as a slacker or medalled as a hero.

XII. Sugar and diabetes.

There is a widespread belief that sugar is responsible for diabetes. In certain quarters it has been blamed for cancer and rheumatism as well. A recent careful examination of the data has shown, however, that there is no justification for these beliefs. On the other hand, Dr. Ralph Pemberton of Philadelphia has recently credited it with conferring some resistance against certain diseases. It is further significant that, in certain varieties of corn and wheat, a positive correlation has recently been established between the sugar contents of the sap and resistance against certain fungus diseases. I have already stated that in the earlier days—when the world supply of this article was scarce—sugar found considerable use in medicine. It might again prove useful in this direction. Antiseptic properties have been claimed for it and it is one of our best preservatives for fruit as illustrated by the jam trade.

XIII. Conclusion.

It is certainly pleasing to our vanity to be told that our country was probably the original home of the sugarcane. But the fact by itself is neither a consolation nor a help in our present unhappy dependence on outside countries for this admittedly valuable article of food even to meet our own needs. It is no consolation for a bankrupt during his darker hours to remember that once he too had plenty of the good things of the world. The remembrance would only increase the misery of the subsequent unhappy situation.

Deplorable as our present condition is, the future outlook is, if anything, the gloomier. At present our consumption of sugar per capita is between a fourth and a fifth of what it is in the most advanced countries of the world. As our consumption increases with the advance of time—it is bound to and has steadily done so in the past—our dependence would only increase, if effective steps are not taken in the meanwhile. Not only that, sugarcane is a valuable and important crop in the main cane-growing provinces and the loss of the crop through the dumping into the country of cheap foreign sugar would seriously upset agricultural conditions in the country.

In ancient days the Indian sugar bowl was probably the one and only one in the world. To-day, and through our not keeping abreast of the rapid development in other lands, it has become a veritable begging bowl; and India has to stand at the doors of other countries for her needs in sugar. Our area is large, the white sugar belt of North India alone containing an area almost equal to that of Java. The auguries may also be deemed favourable as the first activities of the Central Government have already yielded very encouraging results. It only remains to put more energy into the work so well begun.

AN EFFECTIVE METHOD OF POPULARISING AGRICULTURAL IMPROVEMENTS AMONG RYOTS.

BY

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It is necessary to preface the subject with a description of the several methods which have been adopted in doing "district work", *i.e.*, the introduction of improved systems of cultivation in the ryots' lands. The methods adopted everywhere in the Madras Presidency are more or less similar, but in this article, I shall confine myself to the Trichinopoly and Tanjore Districts which form my jurisdiction.

The main staple food crop in these districts is paddy and it occupies about half of the total area under cultivation. Hence work was concentrated on this crop and the improvements brought to the notice of ryots have been the following :—

(i) Use of improved strains of seeds.

(ii) Economic planting of seedlings raised in thinly sown nurseries.

(iii) Use of light iron ploughs.

(iv) Adoption of better systems of preserving cattle manure, raising of green manure crops, use of cheap phosphatic manures, etc.

The work of bringing home to the ryots the agricultural improvements of proved value with a view to enhancing the crop yields in this circle, may be said to have dated from 1915. At this period, only one or two subordinate officers were available for the work and the best use of them was made. In the beginning the usual method adopted was to meet ryots in their villages, learn from them their agricultural practices, and then suggest to them suitable improvements and also demonstrate the same wherever and whenever possible. In most villages visited, there was some response to the advice of the itinerating agricultural officers but, as a rule, one or two ryots only interested themselves in the improvements ; others generally laughed at them until they saw the actual worth of the improvements. Even then they would attribute the superiority of the crop to some imaginary favourable conditions of their friends' lands and not to the improved methods of cultivation. As was natural under the above circumstances, the progress of our work was slow. In addition to the above method of diffusing the knowledge of improved systems of cultivation, leaflets, pamphlets, villagers' calendars, etc., dealing with the subject were distributed broadcast among the ryots. Several ryots were also taken to the Government farms and the work done there explained to them. They often had a

chance to see with their own eyes the working of the improved implements, superior systems of cultivation, etc. All these had some effect, but the sum total was not of the magnitude which was wished for.

Some five years back, in addition to the usual propaganda work, an attempt was made to introduce agricultural improvements by means of what are known as demonstration plots, *i.e.*, by carrying out the several agricultural improvements in central villages on ryots' own lands at their expense but under the supervision of agricultural officers.

By this time, more subordinate staff, though not to the required extent, had been appointed and so the demonstrations could be given in several centres. As far as possible, these plots were arranged by the roadside so as to be in view of passers-by who are mostly ryots and to make them observe the crops and study the efficacy of the improvements without suspecting anything or anybody for the better appearance of the crop grown under the improved system. Parties of ryots were taken to these plots during the growing period of the crop. This system had the desired effect of removing from the ryots' minds the erroneous idea that the superiority of the crop was due to some special cause other than the improved method. After the inception of the demonstration plots, more ryots began to adopt the improvements but even then the progress of our work was not up to expectation.

Thinking that co-operative societies would be the best media for diffusing knowledge of agricultural improvements, existing co-operative credit societies were approached to carry out demonstrations with a view to make their members take interest in the work. Several societies readily undertook this work, but with the exception of the Secretary or President or a solitary member who ran the demonstrations, the society, as a whole, did not care much for the work, with the result that the progress made was not very encouraging. The reason is not far to seek. For most of such societies consist of members whose sole object is borrowing money. Further, the rules of the credit societies did not admit of their taking up this sort of work.

So much for the several successive steps taken in attempting to bring home to ryots improved methods of cultivation. I now come to the subject proper of my article, *i.e.*, an effective method of popularising agricultural improvements among ryots. As all the systems described above did not meet with the desired success, an effort was made in the year 1925 for the first time to form special co-operative societies for our purpose by clubbing together as many ryots as possible interested in agricultural improvements and to carry on our work through them. These are known as co-operative agricultural societies.

In the same year one such society was started at Lalgudy, which was blessed by the then Development Minister, Sir Sivagnanam Pillai, and was started by him. It is known as the Lalgudy Sivagnanam Co-operative Agricultural Society, Ltd. The main object of such a society is to demonstrate agricultural improvements recommended by the department on a field scale with the necessary check plots on

the lands of members or others taken on lease for a fixed rent, and to stock seeds, manures, improved implements, etc., for distribution to members and non-members. Suitable bye-laws were framed by the Deputy Registrar of Co-operative Societies, Trichinopoly, to carry on this work.

In the case of such a society taking a block of land on lease for running the demonstration area, the question as to how to make good the loss, if any, due to seasonal vagaries, naturally arose, and the difficulty was got over by arranging with one or more members to run the demonstration on their lands (about 10 acres in extent) under the following terms :—

(i) The individuals running the demonstration area to get advances of requisite seed, manure, and wages of coolies from the society.

(ii) The advances to be returned to the society at harvest together with a moiety of the extra net profit due to the improvement; but the loss, if any, is not shared by the society.

Now coming to the Lalgudy Sivagnanam Co-operative Agricultural Society about 9½ acres of double-crop wet lands situated by the road-side were taken on lease on a fixed annual rent of 30 *kalams* of paddy (2,800 lbs.) per acre. In about 2 acres of this area, the various improvements in respect of the paddy crop as noted on page 177 were demonstrated each separately and all in one combination, and in one acre the local system of cultivation was adopted which served as the control plot. The remaining portion (6½ acres) was cropped according to the improved method. In addition to this important work this society acted as an agent for the supply of special manures, improved implements, selected seeds, etc. At the end of one year of its existence, stock of the work done by the society was taken and it was gratifying to note that it had done its duty to a fair extent. In this connection it is perhaps not out of place to make mention of the fact that it is very difficult to persuade ryots to form agricultural societies and that much care and circumspection are necessary in starting them and that only the best human material can be used. Further, a good deal of direct supervision is necessary in the beginning in conducting the demonstrations, as this is a new venture. Probably departmental help can be gradually withdrawn as they become accustomed to their work. As the first attempt was encouraging, some more societies were started last year—two in the Trichinopoly District (Nerur in the Karur taluk and Musiri) and two in the Tanjore District (Tanjore town and Mulangudy in the Mannargudy taluk) and a sixth one was organized a few days ago at Maruthur (Kulitalai Taluk) which was christened after Mr. Anstead, Director of Agriculture, Madras, who had the honour of giving a start to the society and opening the demonstration area. The work done by these societies is on the whole encouraging though it is as yet too early to say anything, with full certainty, in favour of or against them. The results of the demonstrations conducted last year (1926-27) in some of the above societies are tabulated.

The results speak for themselves and the general superiority of the improved systems has appealed to the mind of many a ryot-member and non-member—which is evident from the fact that more people are adopting one or more of the improvements. As a further test of the utility of these agricultural societies, there has been a greater purchase of improved implements, seeds and manures from these societies, as may be seen from the figures given below :—

	Rs.	A.	P.
Value of seeds multiplied and sold	977	15	0
Value of manures sold	2,883	2	0

The foregoing facts lead one to conclude that co-operative agricultural societies specially formed for the purpose are perhaps the best means of easy and quick introduction of agricultural improvements ; but much spade work has yet to be done and a net work of societies has to be introduced for the amelioration of the whole lot of agriculturists who form over 70 per cent. of the population. I also think that the rules of these societies require some modification, especially in respect of their borrowing power, as money is required for everything. But these are details which vary from place to place.

In addition to the work noted above, these societies can legitimately undertake joint-silt-clearance from irrigation channels, propagation of strains of seeds on a larger scale, etc. Now they serve as only small centres for seed multiplication.

It cannot for a moment be said that the requisite co-operation exists among the members, in spite of the special care taken in selecting them, but it is earnestly hoped that it will be forthcoming in course of time and that more societies will spring up as a consequence.

Results of demonstrations of Agricultural improvements conducted in 1926-27 by some co-operative agricultural societies in Trichinopoly and Tanjore Districts.

Field No. and area Ac. cents	Treatment: Cultural	Treatment: Manurial	Yield in lb. of grain: Per plot	Yield in lb. of grain: Per acre	Cost of cultivation per acre: Preparatory and after cultivation	Cost of cultivation per acre: Manure	Cost of cultivation per acre: Total	Value of produce per acre	Net profit	Extra profit due to improvements	Remarks
					Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	
	Results of the Samba Crop of the Co-operative Demonstration area—Musiri 1926-27. *Each improvement demonstrated separately (other operations being same).*										
No. 7 0·23	*Local method.*—4 ploughings with country plough, seed rate @ 68¾ lb. and local seed.	2,000 lb. leaf per acre.	653	2,860	43 13 4	12 8 0	56 5 4	156 0 0	99 10 8	..	*N.B.*—Cost of leaf = 6-4-0 per 1,000 lb. Bonemeal Rs. 5-0-0 per cwt. Paddy @ 18⅓ lb. per rupee.
0·22	*Economic Planting.*—Seed rate 25 lb. per acre.	....	697	3,190	37 13 4	12 8 0	50 5 4	174 0 0	123 10 8	24 0 0	
0·22	*Improved manure* . .	Bonemeal 1 cwt. and leaf 2,000 lb. per acre.	724	3,300	43 13 4	17 8 0	61 5 4	180 0 0	118 10 8	19 0 0	
0·22	*Deep ploughing.*—3 ploughing with Konkan ploughs.	2,000 lb. leaf per acre.	795	3,154	41 13 4	12 8 0	54 5 4	172 0 7	117 11 3	18 0 7	
0·17	*Strain.*—Nellore Samba bulk seed.	Ditto . .	596	3,520	37 10 8	12 8 0	50 2 8	192 0 0	141 13 4	42 2 8	
0·21	*All Improvements.*—Ploughing with iron plough twice, economic planting, N. S. bulk seed. Seed rate 25 lb. per acre.	Bonemeal 1 cwt. and leaf 2,000 lb. per acre.	807	3,960	35 11 8	17 8 0	53 3 8	216 0 0	162 12 4	63 1 8	
No. 8 0·86	*Local method.*—Ploughing with country plough twice, local seed and bunch planting 68¾ lb. per acre.	2,000 lb. leaf per acre.	2,466	3,080	43 13 4	12 8 0	56 5 4	168 0 0	111 10 8	..	
0·80	*All Improvements.*—3 ploughings with iron plough, economic planting seed rate 25 lb. per acre. N. S. Bulk Seed.	Bonemeal 1 cwt. and leaf 2,000 lb. per acre.	3,360	3,960	35 11 8	17 8 0	53 3 8	216 0 0	162 12 4	51 1 8	

Results of demonstrations of Agricultural improvements conducted in 1926-27 by some co-operative agricultural societies in Trichinopoly and Tanjore Districts—continued.

Field No. and area Ac. cents	Treatment: Cultural	Treatment: Manurial	Yield in lb. of grain: Per plot	Yield in lb. of grain: Per acre	Cost of cultivation per acre: Preparatory and after cultivation	Cost of cultivation per acre: Manure	Cost of cultivation per acre: Total	Value of produce per acre	Net profit	Extra profit due to improvements	Remarks
					Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	
	Results of the 1st Crop (Kuruvai) in the Co-operative Demonstration area, Palli-Agraharam, Tanjore, 1926-27.										
No. 2 1—24	*Local Method.*—5 ploughings with country plough, bunch planting (seed rate 90 lb. per acre).	12 cartloads of cattle manure per acre.	345	1,438	31 13 0	12 0 0	43 13 0	71 14 5	28 1 5	..	*N.B.*—Cost of cattle manure =1 Re. per cart load. Ammonium sulphate Rs. 8-8-0 per 80 lb. Super Rs. 5-2-0 per cwt. value of paddy @ 20 lb. per rupee.
No. 1 1—48	*All Improvements.*—3 ploughings with Konkan plough, economic planting (seed rate 35 lb. per acre).	6 cartloads of cattle manure, 40 lb. of Ammonium sulphate and 1 cwt. super per acre.	780	1,814	24 7 9	15 6 0	39 13 9	90 11 2	50 13 5	22 12 0	
No. 5(*b*) 0·20	*Local Method.*—5 ploughings with country plough, bunch planting (seed rate 90 lb. per acre).	12 cartloads of cattle manure per acre.	250	1,250	31 6 3	12 0 0	43 6 3	62 8 0	19 1 9	..	
No. 5(*b*) 0·20	*All Improvements.*—3 ploughings with Konkan plough and Economic planting (seed rate lb. per acre).	6 cartloads of cattle manure, 40 lb. of Ammonium sulphate and 1 cwt. super per acre.	342½	1,712½	24 12 8	15 6 0	40 2 8	85 10 0	45 7 4	26 5 7	
	Results of the Single crop (Samba) in the Co-operative Demonstration area, Palli-Agraharam, Tanjore District, 1926-27. *Each improvement demonstrated separately, other operations being common and also all improvements in one combination.*										
No. 10 0·8	*Local method.*—5 ploughings with country plough, bunch planting (seed rate 90 lb. per acre). Local, N. S. seed.	12 cart loads of cattle manure per acre.	76	950	33 1 8	11 15 8	45 1 4	47 8 0	2 6 8	..	
0·8	*Economic planting* .	Ditto . .	130	1,625	30 6 1	11 15 8	42 5 9	81 4 0	38 14 3	36 7 7	*Note.*—Value of paddy=20 lb. per rupee cost of cattle manure 1 rupee per cartload Ammonium sulphate Rs. 8-8-0 per 80 lb. super Rs. 5-2-0 per cwt.
0·8	*Improved manure* . .	40 lb. Ammonium sulphate+112 lb. of super+6 cartloads of cattle manure per acre.	125	1,562½	33 1 8	15 5 10	48 7 6	78 2 0	29 10 6	27 8 10	
0·8	*Strain.*—A. 5 Nellore Samba.	12 cartloads of cattle manure per acre.	120	1,500	33 1 8	11 15 8	45 1 4	75 0 0	29 14 8	27 8 0	

0·8	*Deep ploughing.*—3 ploughings with Konkan plough.	Ditto . .	112½	1,406	27 1 5	11 15 8	39 1 1	70 4 10	31 3 9	28 13 1
0·8	*All improvements.*—3 ploughings with Konkan plough, economic planting (seed rate 14 lb). Strain A. D. T. S. (Nellore Samba).	40 lb. Ammonium sulphate +112 lb. super +6 cartloads cattle manure per acre.	130	1,625	24 5 8	15 5 10	39 11 6	81 4 0	41 8 6	24 1 10

RESULTS OF THE 1ST CROP KURUVAI IN THE LALGUDI SIVAGNANAM CO-OPERATIVE AGRICULTURAL SOCIETY, 1925-26.

0·36	*Local method.*—5 ploughings with country plough bunch planting, seed rate 75 lb.	16 cartloads of cattle manure.	878½	2,440	30 10 1	24 0 0	54 10 1	122 0 0	67 5 11	..	*N.B.*—Cost of cattle manure Rs.1-8-0 a cartload. Bonemeal Rs. 5 per cwt. Value of paddy 20 lb. per rupee.
0·36	*All improvements.*—3 ploughings with Konkan plough, economic planting, seed rate 37½ lb.	8 cartloads of cattle manure +84 lb. of bonemeal + 1,500 lb. of green leaf grown in *situ*.	1,373½	3,185	[illegible] 13 11	18 0 0	51 13 11	159 4 0	107 6 1	40 0 2	
0·20	*Deep ploughing.*—3 ploughings with Konkan plough, bunch planting, seed rate 75 lb.	Ditto . .	512½	2,562	41 7 10	18 0 0	59 7 10	128 1 8	68 9 9	1 3 10	
0·36	*Economic planting.*—Seed rate 37½ lb.	Ditto . .	849	2,636	31 4 0	18 0 0	49 4 0	131 12 10	82 8 10	15 2 11	
0·36	*Improved manure* . .	Ditto . .	960	2,945	35 6 4	18 0 0	53 6 4	147 4 0	93 13 8	26 6 9	

RESULTS OF THE 1ST CROP (SARAPALI) IN THE LALGUDI SIVAGNANAM CO-OPERATIVE DEMONSTRATION AREA 1926-27.

1(*b*) 0·25	*Local method.*—4 ploughings with country plough, bunch planting (seed rate 90 lb. per acre).	*Kuppai* (Village rubbish) 8 tons per acre.	665	2,660	31 12 8	25 6 8	57 3 4	119 0 0	61 12 8	..	*N.B.*—One ton *Kuppai* =2 cartloads value of *Kuppai* (village rubbish), 3-2-0 per ton. Bonemeal = 5-14-0 a cwt. green manure =actual cost of seed taken in to account. Value of paddy = Rs. 4-7-7 per 100 lb. Straw weight not taken into account.
1(*a*) 0·25	*Improved method.*—3 ploughings with iron plough, economic planting (seed rate 37½ lb. per acre).	Bonemeal 84 lb. *Kuppai* 4 tons per acre and green manure crop grown in *situ* (approximate quantity of leaf got was at 1,000 lb. per acre).	820	3,280	24 11 4	19 4 4	[illegible]3 15 8	146 11 11	102 12 3	40 15 7	
1(*d*) 0·28	*Local method.*—4 ploughings with country plough, bunch planting (seed rate 90 lb. per acre).	*Kuppai* 8 tons per acre.	590	2,360	31 13 8	25 6 8	57 4 4	105 9 3	48 4 11	..	

Results of demonstrations of Agricultural improvements conducted in 1926-27 by some co-operative agricultural societies in Trichinopoly and Tanjore Districts—(concld).

Field No. and area Ac. cents	Treatment		Yield in lb. of grain		Cost of cultivation per acre			Value of produce per acre	Net profit	Extra profit due to improvements	Remarks
	Cultural	Manurial	Per plot	Per acre	Preparatory and after cultivation	Manure	Total				
					Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	
1(c) 0·25 0·25	*Improved method*.—3 ploughings with iron plough, economic planting (seed rate 37½ lb. per acre).	Bonemeal 84 lb. *Kuppai* 4 tons per acre and green manure crop grown *in situ* (approximate quantity of leaf 1,000 lb. per acre).	665	2,660	25 2 4	19 4 4	44 6 8	119 0 0	74 9 4	26 4 5	
4(a) 0·60	*Local method*.—4 ploughings with country plough, bunch planting (seed rate 90 lb. per acre).	*Kuppai* 8 tons per acre and green manure crop grown *in situ* (quantity of leaf obtained 1,000 lb. per acre).	1,639	2,732	31 1 8	28 14 11	60 0 7	122 3 8	62 3 1	..	
4(b) 0·60	*Improved method*.—3 ploughings with iron plough, economic planting (seed rate 37½ lb. per acre).	Green leaf 1,000 lb. *Kuppai* 4 tons and bonemeal 84 lb.	1,793	2,988	24 12 5	19 10 5	44 6 10	133 10 11	89 4 2	27 1 0	

RINDERPEST: ACTIVE IMMUNIZATION BY MEANS OF THE SERUM SIMULTANEOUS METHOD; GOAT VIRUS.

BY

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Directions for the application of this method of preventive inoculation, to confer upon cattle a durable immunity against rinderpest, have appeared already in this *Journal* (1925, November, Vol. XX, Part VI, p. 431). It was stated in that article that cattle subjected to this treatment were not infrequently exposed to considerable risk from the almost inevitable concomitant introduction of piroplasms with the "virus" used in the inoculation. The nature of these piroplasms and the disease they set up has been described at some length in an article that appeared recently in this *Journal* (1927, November, Vol. XXII, Part VI, pp. 411—421), entitled, "The Acclimatization of Imported Stock."

Researches have been prosecuted on a considerable scale at Muktesar lately with the object of purifying the virus, at any rate to the extent of eliminating from it any accompanying piroplasms that are noxious for cattle in the manner described above. We have succeeded in achieving this end by causing the virus to propagate in bodies of small ruminants which are not susceptible to infection by the cattle piroplasms, but which ordinarily are resistant to rinderpest. The small ruminant chosen for the routine propagation of the virus is the goat. We know that natural outbreaks of rinderpest occur sometimes in this species, although in the scene of outbreaks of severe rinderpest among cattle in India it nearly always escapes attack. Likewise, in the laboratory it is almost impossible to maintain the infection alive in goats by the customary laboratory methods: after inoculation of a goat with the ordinary cattle virus the infection may persist in its blood, in minute amounts, intermittently, for a long time, but it is not possible to transmit this infection from the infected goat to a healthy goat; contrary to what has been said recently by certain authorities, the blood of a goat infected in this way is not reliable for use in the serum-simultaneous method of inoculation, for the reason that it is not always certainly virulent.

The means adopted at Muktesar to "fix" the rinderpest virus on goats will be described later at some length in technical publications; a brief reference to them has been made in the Annual Report of the Institute for 1926-27 and also in a short paper read before the recent Meeting of the Far Eastern Association of Tropical Medicine and Hygiene at Calcutta. It has been

felt, however, that the notice of the stockowner and veterinary worker in the field should be drawn early to the important modification in the system of the serum-simultaneous method of inoculation which is now capable of employment as the result of this research. The modification has been extensively tested at the laboratory for over a year, and is now undergoing application in the field.

The practice of this modification is described in an Addendum to the most recent edition (now in the press) of the circular directions for undertaking the serum-simultaneous inoculation. This Addendum is reprinted below :—

Goat Virus.

A. What has been said in this pamphlet upon "*virulent blood*" for use in the serum-simultaneous method of inoculation against rinderpest (page 4) may be modified now considerably with great advantage as the outcome of recent research. It has become possible to "fix" the rinderpest virus upon goats, and to "passage" it successfully in these animals, that is, to pass the infection on readily from goat to goat, by inoculation of small quantities of blood from affected goat to healthy goat.

B. The advantages of using virus from goats are, briefly, the following :—

(*a*) The virus is "cleansed" of the cattle piroplasms (described in this pamphlet, pages 6 and 7) by passage through the bodies of goats : the piroplasms of cattle cannot infect goats.

(*b*) The virus has been found to possess a somewhat "fixed" or steady virulence, often considerably lower than that of the virus obtained direct from cattle ; hence, it is generally safer.

(*c*) It can be despatched from the laboratory in small glass containers, for inoculation into goats readily by the operator himself, who can then manufacture unlimited supplies of fresh and reliable virus for his immediate use from these cheap and easily procurable animals.

(*d*) There is not likely to be the same sentimental objection to the use of goats as of cattle as virus producers among the Hindu population.

(*e*) By observing the reactions in the goats inoculated by him for the provision of virus, the operator can make himself reasonably assured that he is actually inoculating living virus into the cattle to be immunised. This is not so when the virus has been received in bulk long distances from the laboratory. The operator may feel confident therefore that the serum used for injection simultaneously has not been wasted, or at least, conferred merely a temporary immunity, such as would have been obtained by the serum-alone method.

C. The procedure recommended is the following :—

(i) When the operator wishes to inoculate cattle by the serum-simultaneous method in any locality he should telegraph his needs in goat virus to

the laboratory—whenever possible, four days in advance of the date when the virus is to be despatched from the laboratory.

(ii) A consignment, comprising three glass ampoules, each containing about 5 c. c. of goat virus, will then be despatched from the laboratory to the consumer by registered parcel post, and telegraphic confirmation sent to him of the despatch.

(iii) The operator meanwhile should procure two goats that are healthy, mature in age, and in fairly good condition. On arrival of the consignment of goat virus, the *mixed* contents of the ampoules should be injected *at once* subcutaneously into these goats.

(iv) The temperatures and clinical appearances of the goats should then be noted daily, morning and evening, and if the virus has not perished there will be observed, on the 3rd day usually, a very distinct rise in temperature. Subsequently, the goats will show malaise—rough upstanding coat, discharge from nose, inappetence.

(v) If the inoculated goats do not show a distinct rise in the temperature by the fourth or fifth day after injection, it means very likely that the virus had perished in the blood received from the laboratory by the time it was received, and the goats cannot then be used for the provision of virus for the inoculation of the cattle by the serum-simultaneous method. In this event, the operator should telegraph to the laboratory for a further supply of virulent goat blood before commencing inoculations.

(vi) If the goats show an undoubted reaction, as described in para. (iv), they may be bled for virus on the fourth or fifth day after inoculation. At this interval, it has been found in the laboratory sometimes that one-tenthousandth of a cubic centimetre of the goat blood is virulent, and so the operator may use any convenient small quantity—from $\frac{1}{4}$ to 1 c. c.—for the inoculation of the cattle to be subjected to the serum-simultaneous method of immunization.

(vii) The blood is run out of the jugular vein by means of a suitable hypodermic needle into a clean glass vessel, that has been sterilised by boiling beforehand. To prevent clotting of the blood, the vessel should contain about one-tenth its capacity of a four per cent. solution of potassium or sodium citrate (boiled beforehand), which is then well mixed with the blood as soon as it is run in, or else some strands of metallic wire or glass beads to defibrinate the blood by vigorous shaking for some minutes after it has been let into the flask. In fact, this process of defibrination can be readily carried out still more simply by running the blood quickly from the vein, through a fairly wide bored hypodermic needle, into a small metal or earthenware pot, such as an empty jam jar, that has been cleaned and boiled

and whipping the blood briskly for a few minutes with a bundle of wire "twigs," until the fibrin of the blood separates out on the twigs.

(viii) Inoculation of the cattle with serum should not be commenced until the operator is assured, from his observations on the goats, that they are likely to yield good virus.*

(ix) The blood from the two reacting goats should be mixed together for the inoculation, for we have found that the blood of individual goats may be occasionally rather poor in virus, even though they show a high temperature reaction.

(x) It is a good plan to inoculate two more goats at once from the reacting goats when blood is being taken from them for the inoculation of the cattle by the serum-simultaneous method. These two goats will then serve as "controls," when observations are made on them daily, to confirm the operator's belief if they should react that the blood inoculated into the cattle was really virulent. Further, if all the cattle are not treated at once, it will be necessary to multiply the supply of available virus in this manner for subsequent use. In fact, the virus may be readily propagated indefinitely in this manner, by the inoculation of fresh goats every four or five (or even more) days from reacting goats.

(xi) In any event, we strongly advise the operator as a first step to immunise only a small number of cattle—say 6 to 10, or a small proportion (about 10 per cent.) including representatives of all the kinds of cattle which he desires eventually to treat in this way. His observations upon this preliminary batch will enable him to ascertain whether or not he has administered serum of proper quality and quantity and will give him the degree of confidence he requires for the wholesale treatment of the animals in his veterinary charge.

D. Orders for goat virus, when despatched by telegram, should indicate plainly that goat virus is required. As the quantity issued will be the same for

* For country cattle particularly, which have a fairly high natural resistance towards rinderpest, we now recommend wholesale inoculation of cattle by the serum-simultaneous method by injecting them with a flat rate dose of serum, say 30 c. c. (but not less than this amount) and then inoculating them all with a little goat virus at the time they are injected with serum, with little more ado than if they were injected with serum by the serum-alone method, except that we recommend, as a matter of precaution, that they should not be moved or worked among healthy, uninoculated cattle for a week or two after they have been injected. In the scene of outbreaks of rinderpest, this system may also be adopted with great advantage upon the healthy contact cattle, that the authorities would otherwise inoculate by the serum-alone method; thus a passive immunity lasting a few days only can be transformed into an active one, lasting two years or much longer, by the injection of a little goat virus simultaneously with the serum, which itself for safe use by this method need only be about double in amount what would have to be used for reliable protection by the serum-alone method.

compliance with all orders (see B (ii), above) it will be sufficient to state on the telegram, for example;—" Sera, Ritani, Despatch goat virus to leave Muktesar (give exact date) to (give exact postal address)—(telegraphic designation of indenting authority)." As indicated also above, four days' notice of order should be given whenever it is possible to do so. What has been said (page 3) upon the length of time the virus remains alive in blood applies to the goat virus as to the bull virus at least equally in so far as it has been laid down that it perishes in any event after a few days.

GERMINATION OF SU ARCANE POLLEN IN ARTIFICIAL CULTURE MEDIA.

BY

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I. Introductory and historical.

For employing a variety as parent in sugarcane breeding, it is essential to have some knowledge of the fertility or otherwise of its pollen. Such knowledge enables the breeder to decide if the variety in question is to be used as a male or female parent in breeding operations. Anthesis percentages help in such a decision, for instance, 60 to 100 per cent. open anthers in a variety indicate its use as a pollen parent. As however the pollen liberated from an open anther may include any percentage of immature or rudimentary pollen which will not germinate, it becomes necessary to make germination tests before deciding about the use of any variety for pollination.

Since the earlier attempts of von Mohl (1834), Schleiden (1849) and Van Tieghem (1869), pollen of various genera and species of both *monocotyledons* and *dicotyledons* have been germinated artificially in culture media, but not with uniform success in every case. The various factors governing the germination of pollen are far from having been completely determined and the problems connected with pollen physiology still await solution.

The artificial germination of pollen of grasses, in particular, has not been an easy task, though Andronescu [1] and Anthony and Harlan[2] have succeeded in readily germinating maize and barley pollen respectively. The attempts made at Coimbatore and elsewhere to germinate sugarcane pollen in artificial culture media

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[1] Andronescu, D. I. The Physiology of the pollen of *Zea Mays* with special regard to vitality, 36 p., 4 pl. (Urbana, Ill) Reference list, 1915.

[2] Anthony, S., and Harlan, H. V. Germination of barley pollen. *Jour. Agri. Res.*, Vol. XVIII, No. 10. pp. 525 to 536.

have, so far, given very discouraging results.[1] Strasburger in 1886 established the fact that pollen of one species will germinate on the stigmas of very different species of plants, the pollen of a *monocotyledon* germinating on the stigmas of a *dicotyledon* and *vice versa*. The failure to germinate cane pollen in culture media naturally led to trials being made on the live stigmas of other plants. Venkatraman [2] obtained satisfactory results with the stigmas of *Datura fastuosa* var. *alba* after a trial of over sixty species. In his trials, germinations were also obtained on the stigmas of *Carica Papaya*, *Hibiscus vitifolius*, *Gynandropsis pentaphylla* and *Thespesia populnea* ; but *Datura* was finally selected as the standard and has all along been used at the Imperial Sugarcane Breeding Station, Coimbatore, for testing the viability of cane pollen. Cottrell-Dormer [3] and Mercado [4] have used the fresh sugarcane stigmas for pollen viability tests. The results are no doubt satisfactory, but the minuteness of the cane flower and the abundance of stigmatic hairs seem to be handicaps. Barber [5] has described a " direct " method of germinating sugarcane pollen based on the observations of K. V. R. Badami. In this method no culture medium is employed and the only requisite seems to be the proper adjustment of moisture, so that it is reduced to a minimum.

The above statements and the importance of the subject to sugarcane breeding suggested the retrial of various culture media for germinating cane pollen artificially.

II. Material and methods.

The Cane Breeding Station at Coimbatore affords unique opportunities for sugarcane pollen studies inasmuch as it has to grow a large assortment of cane varieties and seedlings for breeding purposes. While this is a great advantage in so far as it presents a wide field for the choice of material, the fact that the majority of canes comes into flower within a short interval of time, *viz.*, about two months from middle of October to middle of December, greatly limits the scope of extended study.

The other handicap, so far as the material is concerned, is that there is a good deal of variation in the nature of the available pollen. This variation is observed to occur not only in different arrows of the same variety but also in different por-

[1] From an abstract of Weller's article on sugarcane pollen studies received at the time of writing (March 1927) it appears that certain amount of success was obtained with artificial culture media.
Weller, D. M. Sugarcane pollen studies. *Hawaiian Planters' Record*, Vol. 30 (1926), pp. 400-414, *Facts About Sugar*, Vol. XXI, Novr. 6, 1926, p. 1063.

[2] Venkatraman, T. S. Germination and preservation of sugarcane pollen. *Agri. Jour. India*, Vol. XVII, Pt. II, March 1922, pp. 127-132.

[3] Cottrell-Dormer, W. Studies on fertility of sugarcane flowers. *Planter and Sugar Manufacturer*, Vol. LXXIII, No. 20, pp. 389-391.

[4] Mercado, T. Study of the flowering habits and flower characteristics of three varieties of sugarcane. *Philippine Agriculturist*, Vol. XV, No. 4, Sept. 1926, pp. 181-204.

[5] Barber, C. A. A direct method of germinating sugarcane pollen grains. *International Sugar Journal*, Vol. XXVII, July 1924, pp. 358-359.

tions of the same arrow and from spikelet to spikelet. Further, the anthers differ markedly as regards time of opening and there is considerable amount of variation in size, contents and shape.

The works of Anthony and Harlan [1] on barley pollen, of Martin [2] on pollen of *Trifolium pratense*, of Adams [3] on pollen of apple and of Brink [4] on *vinca* pollen, etc., have demonstrated that different kinds of pollen need different treatment for artificial germination. Some require only suitable moisture conditions for the production of pollen tubes, while with others the sugar and other requirements have to be very exact.

Our first attempts in germinating sugarcane pollen were directed towards the control of moisture and air supply. The pollen readily burst in excess of water and got shrunk when moisture was completely withheld. For the determination of the requisite amount of moisture for germination, a series of experiments was laid covering a wide range. A second series was designed to determine the requisite amount of air. After trials a glass ring 7·5 mm. high and 17 mm. in diameter with two to three drops of culture medium at the bottom was found to be the most satisfactory moist chamber. The advantage of putting two to three drops of culture medium as a source of moisture supply in place of moistened filter paper, drops of water or mesophyll, consists in the fact that the vapour pressure equilibrium is maintained, no water evaporating from below and depositing on the culture medium above and *vice versa*.

The next aim was to ascertain the suitable culture medium. Attempts with dextrose, fructose, maltose, lactose and galactose met with no success. Addition of 1 per cent. agar to the above sugars did not make any improvement. Twenty-six per cent. of maltose and 17 per cent. dextrose with less than 1 per cent. agar gave about half a dozen germinations each. Encouraging results were obtained with sucrose solutions. Various strengths of sucrose solution with about 1 per cent. of agar and without agar were tried. Very low concentrations such as 5 and 10 per cent. of sucrose caused considerable burstings and produced only a few germinations. As the concentration was increased, there were more and more germinations and the bursting decreased. Very high concentrations, *e.g.*, 40 and 50 per cent., on the other hand, inhibited germination and the contents plasmolised. Best results were obtained with concentrations ranging from 23 to 30 per cent. sucrose combined with about 1 per cent. agar.

As a result of repeated trials, the following technique for the germination of sugarcane pollen was finally adopted as the most satisfactory. Chemically pure cane

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[1] *loc. cit.*

[2] Martin, J. A. The physiology of the pollen of *Trifolium pratense*. *Bot. Gaz.*, Vol. 56, pp. 112, 126, 1913.

[3] Adams, J. On the germination of the pollen grains of apple and other fruit trees. *Bot. Gaz.*, Vol. 61, pp. 131-147, 1916.

[4] Brink, R. A. The physiology of pollen. *Amer. Jour. Bot.*, Vol. XI, Nos. 4, 5, 6, 7, April, May, June, July, 1924.

sugar (sucrose) is dissolved in distilled water to give a strength of 26 per cent. sucrose, and 0·7 per cent. agar is added. The solution is boiled for a minute or two to dissolve the agar and cooled again to the room temperature. A glass ring 7·5 mm. high and 17 mm. in diameter is vaselined on the top and bottom and placed over the cavity of a hollow ground slide. Two to three drops of the above culture medium are placed in the hollow. A small drop of the medium is then put on a clean cover slip and spread to a thin layer with a glass rod. The pollen is then dusted on the medium and the cover slip inverted over the moisture chamber. The vaseline makes the chamber fairly air proof which seems to be a necessary perquisite. The moist chamber is then left at the room temperature (23-26° C.).

The percentages of germination were worked out by putting the slide with the moist chamber on a mechanical stage and gradually going over the field. A micrometer marked into squares was put into the eye-piece to ensure that germinated pollen grains already counted are not once again taken up. In making the counts, the illformed or rudimentary grains were discarded.

III. Results obtained.

(i) *Comparative viability of a few varieties of sugarcane.*

The pollen of the undermentioned varieties was put for germination in 26 per cent. sucrose *plus* 0·7 per cent. agar culture medium. The pollen of the varieties La Purple, Red Ribbon, Purple Mauritius, Maur. 131, Manjri Red, B. 6388, D. 74, D. 131, P. O. J. 1410, P. O. J. 1499 and P. O. J. 2696 was obtained from a crop grown under wet land conditions, while that of the rest was got from a crop grown on a stiff and rather saline soil. Portions of arrows were cut about one hour before the opening of the anthers and were brought to the laboratory with the base of the cut portion placed in a bottle of water.

TABLE I.

Viability of pollen of different varieties.

Date	Name of variety	No. of pollen grains sown for germination	No. of germinations obtained	Percentage of germination
3rd November 1926 . .	La Purple . . .	Anthers did not protrude and dehisce and pollen was not liberated freely.		
6th November 1926 . .	Red Ribbon . .	No free shedding of pollen—only 5 or 6 grains obtained—no germination.		
9th November 1926 . .	Purple Mauritius . .	4,760	330	7
15th November 1926 . .	Maur. 131 . . .	6,436	338	5

Viability of pollen of different varieties—contd.

Date	Name of variety	No. of pollen grains sown for germination	No. of germinations obtained	Percentage of germination
16th November 1926 . .	Manjri Red	5,634	890	16
15th November 1926 . .	B. 6388	4,916	171	3
9th November 1926 . .	D. 74	9,809	410	4
13th November 1926 . .	D. 131 . . .	4,420	783	18
10th November 1926 . .	P. O. J. 1410 . .	2,537	515	20
12th November 1926 . .	P. O. J. 1499 . .	7,114	1,096	15
5th November 1926 . .	P. O. J. 2696 . .	8,206	1,508	18
21st November 1926 . .	Co. 290 . . .	1,331	181	14
29th October 1926 . .	M. 54111 . . .	13,565	5,967	44
15th November 1926 . .	M. 54213 . . .	3,273	458	14
7th November 1926 . .	M. 55464 . . .	8,170	2,650	32
23rd November 1926 . .	M. 55599 . . .	3,833	606	16
25th November 1926 . .	Saretha Desi . .	21,735	5,729	26

(ii) *Influence of temparature.*

For the determination of the effects of temperatures, the cultures were put at fixed degrees of temperature (centigrade) in the incubator. The pollen obtained was from cut arrow kept in a bottle of water. These were compared with cultures kept at the laboratory temperature as noted below :—

TABLE II.

Effect of temperature on germination of pollen.

Variety.—Saretha Desi.

Date	Under laboratory conditions			In the incubator	
	——	First test	Second test	First test	Second test
27th November 1926 .	Temperature . .	23°C.	23°C.	27·5°C.	27·5°C.
	No. of pollen grains sown for germination.	2,370	..	4,480	..
	No. of germinations obtained.	185	219	1,035	179
	Percentage of germination.	8	..	23	..

Effect of temperature on germination of pollen—contd.

Variety.—Saretha Desi.

Date	Under laboratory conditions			In the incubator	
	—	First test	Second test	First test	Second test
8th December 1926 .	Temperature . .	27°C.	27°C.	30°C.	30°C.
	No. of pollen grains sown for germination.	..	..	..	..
	No. of germinations obtained.	48	32	63	3
	Percentage of germination.	..	..	..	..
11th December 1926 .	Temperature . .	24°C.	..	30°C.	..
	No. of pollen grains sown for germination.	2,440	..	1,470	..
	No. of germinations obtained.	360	..	435	..
	Percentage of germination.	15	...	30	..

Variety.—M. 54111.

Date		First test	Second test	First test	Second test
12th December 1926 .	Temperature . .	24°C.	24°C.	33°C.	33°C.
	No. of pollen grains sown for germination.	820	846	735	490
	No. of germinations obtained.	423	360	315	225
	Percentage of germination.	52	43	43	46

As will be seen from the above, there is a wide range of temperature in which pollen appears to germinate normally. The laboratory temperature in the morning varied from 22°C. on chilly days to 26 to 27° C. on other days. Good germinations were obtained irrespective of the changes in temperature. At 27, 30 and 33°C. in the incubator, the percentages of germination and the length of the tubes were as good as at lower temperatures, but at 30 and 33°C, there was a tendency to burst.

(*iii*) *Influence of weather.*

Changes in weather conditions influence anther dehiscence to a considerable extent. Bright sunny weather quickens dehiscence of anthers, whereas cloudy weather delays the same, and it might be expected that changes in weather condition would, likewise, have similar influence on the germination capacity of pollen.

The following table, however, shows that germinations were obtained inspite of cloudy or rainy weather :—

TABLE III.

Influence of weather.

Date	Weather	Variety	Total no. of pollen	No. of germinations	Percentage of germination
29th October 1926 .	Previous day sunny; night clear; morning clear.	M. 54111 .	1,035 1,737 1,277 2,172	344 646 455 741	33 37 36 34
3rd November 1926 .	31st and 1st rainy; 2nd clear and sunny; 2nd night cloudy and slight drizzle; 3rd morning clear and sunny.	Do. .	493 1,439 1,236	143 372 473	29 26 38
5th November 1926 .	Previous night a bit cloudy; morning cloudy.	P. O. J. 2696	447 Not counted.	98	22 About 25
6th November 1926 .	Previous evening at 2-30 to 3-20 P.M. sharp rain; night cloudy; morning cloudy; intermittent sun thereafter.	Do. .	1,537 1,354	242 326	16 24
7th November 1926 .	Previous evening cloudy and drizzling; night cloudy and slight drizzle; morning cloudy with intermittent drizzle.	M. 55464 .	931 1,114	236 365	25 33
8th November 1926 .	Previous day cloudy and drizzling; night cloudy; morning cloudy.	Do. .	3,486 2,639	1,187 863	34 33
11th November 1926 .	Previous day and night clear; morning clear and sunny.	Do. .	2,025 762	370 140	18 18
12th November 1926.	Sunny and clear .	Do. .	2,147 2,351	491 603	23 26

(iv) Pollen viability at different periods after dehiscence.

The object has been to find out whether maximum germinations are obtained when pollen is dusted just at the time of dehiscence or at any time after that.

From the data * given below it will be observed that dusting pollen one hour after dehiscence does not materially affect germination.

TABLE IV.

Pollen viability at different periods after dehiscence.

Date.—28th November 1926.

Variety.—Saretha Desi.

Time of dehiscence.—7 A.M.

Time of dusting	Total No. of pollen	No. of germinations	Percentage of germinations
7 A.M.	2,742 1,798	778 228	28 13
7-30 A.M.	3,536 3,085	1,137 1,037	32 34
8 A.M.	Not counted ; many germinations, not less than the previous.		
8-30 A.M.	Not counted ; many germinations, but less than the previous.		
9 A.M.	1,970 2,357	280 288	14 12
Date.—29th November 1926. Variety.—Saretha Desi. Time of dehiscence.—7-15 A.M.			
6-55 A.M.		No germination.	
7-15 A.M.	2,550	598	23
7-45 A.M.	2,730	780	29
8-15 A.M.	3,494	912	26
9 A.M.	3,270	603	18

* Pollen was taken for this test from a growing arrow in the field.

IV. Retention of pollen viability after exposure to free air under different conditions.

It is of considerable importance to the cane-breeder to know exactly when the sugarcane pollen has its maximum viability and how long it is retained after dehiscence. Barley pollen is stated to lose its viability entirely when exposed to air for ten minutes. Pollen of Saretha Desi, a thin North Indian sugarcane variety, was studied with this object under the following conditions :—

(1) When left exposed to atmosphere within the laboratory, and (2) When exposed to atmosphere in direct sunlight.

(i) *On exposure to free air in the laboratory.*

When the anther dehiscence was in full swing, pollen was shaken off from the arrow and gathered together on white paper and germinations tested at different intervals with the following results. A control was also put in, *i.e.*, pollen was sown for germination direct from the dehiscing anthersac.

Table V.

Germinations obtained from pollen exposed to air in the laboratory for different periods of time.

Date.—5th December 1926.
Variety.—Saretha Desi.
Bulk dehiscence.—7-30 A.M.

Time of dusting	Temperature	Duration of exposure to air		No. of germinations obtained		Remarks
		Hours	Minutes	First test	Second test	
A.M.	°C.					
7-30 . .	24			219	179	Control.*
7-45 . .	24	0	5	290	232	
8 . . .	24	0	20	280	380	
8-20 . .	24·5	0	40	189	201	
8-30 . .	24·5	0	50	136	207	
8-40 . .	24·5	1	0	2	480	
8-50 . .	24·5	1	10	93	337	
9 . . .	24·5	1	20	70	34	
9-30 . .	25·5	1	50	26	17	
10 . . .	26	2	20	*nil.*	*nil.*	

Column No. 4, Table V, represents the counts of germinated pollen grains. Total number of grains put for germinations were not counted.

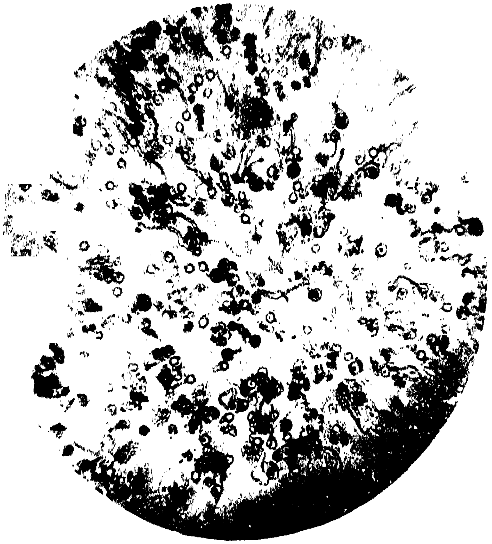


Fig. 1.

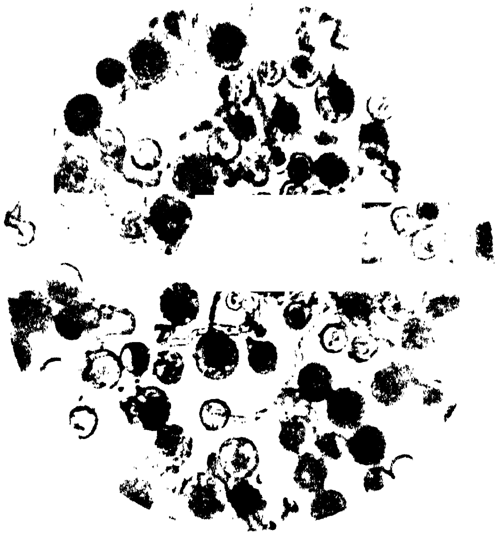
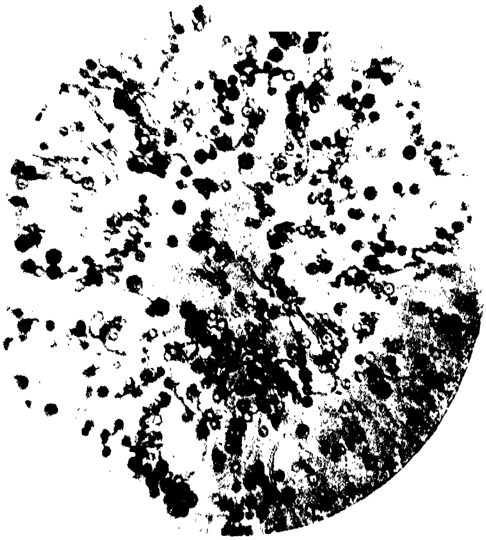


Fig. 2.



Germination of Sugarcane pollen in artificial culture media.

From the above, it will be seen that about one hour's exposure to atmosphere does not very much affect the viability ; but after one and a half hours there is a marked decrease in the number of germinations obtained. After two and a half hours, there were no germinations.

(ii) *On exposure to atmosphere in direct sunlight.*

The pollen was collected on paper as before and exposed to sunlight and temperatures noted at different times of dusting.

TABLE VI.

Germination of pollen on exposure to air in sunlight for different times.

Date.—6th December 1926.
Variety.—Saretha Desi.
Bulk dehiscence.—7-30 A.M.

Time of dusting	Temperature	Duration of exposure to air in sunlight		No. of germinations obtained		Remarks
		Hours	Minutes	First test	Second test	
A.M.	°C.					
7-45 . .	25	0	15	145	275	
8 . . .	27	0	30	153	282	
8-40 . .	29·5	1	10	643	590	
9 . . .	30	1	30	82	188	
9-30 . .	34·5	2	0	2	4	
10-15 . .	35	2	45	*nil.*	*nil.*	

It is interesting that when exposed to the sun also pollen retains its viability to approximately the same time (Pl. XVII, Fig. 3) as in shade. This must be confirmed by more tests.

V. Discussion of results.

The variation in the nature of the available pollen and the delicate adjustment of moisture are the causes, among other factors, of varying germinations in artificial culture media. As pointed out by Brink,[1] the divergent results are not due entirely to the basic differences in the material but to the capricious nature of the pollen resulting in " fluctuations of a minor sort which an imperfectly developed

[1] *loc. cit.*

technique fails to set forth in true perspective." The conditions necessary to secure germination appear to be, (1) a suitable culture medium and the proper concentration of its ingredients, (2) proper adjustment of moisture, (3) temperature, and (4) air. To these may be added the age of pollen according as it is dusted exactly at the time of dehiscence or at fixed intervals after that, the part of the arrow from which the pollen is taken, and the addition of necessary growth-promoting substances.

In the course of the experiment fairly long tubes, about 2 mm. in length, have been met with and the length in proportion to the length of the stigma and the style is satisfactory. Two branched tubes (Pl. XVIII, fig. d) from a single pollen grain are frequently met with and three branched tubes (Pl. XVIII, figs. b and e) also occur. The total length of the pollen tube is consequently much greater. Along with Anthony and Harlan,[1] the writers find that the difficulties of germination do not disappear with a realization of the conditions necessary to secure growth and that it has not been possible to bring all the factors under control.

It has been said that in the pollen which can be made to grow artificially, the growth is appreciably enhanced by the addition of fresh plant tissues and stigmatic decoctions. Brink[2] obtained a regular increase in the growth of the pollen tubes by the addition of raw potato juice and sterile yeast to *cucumis* pollen. Both these substances and some others have not proved a success with sugarcane pollen and the finding out of the particular growth-promoting substance or substances and the definite chemical stimulus must, however, be left to further experiment.

The fact that sugarcane pollen emits tubes in sugar agar medium which have been found to reach a maximum length of about 2 mm. raises the question whether the reserve material contained in the pollen grain (starch in the case of cane pollen) is sufficient to promote the growth to such an extent or whether the reserve material is supplemented by nutrient food from the culture medium. There is no doubt that starch is being utilised by the pollen tube for its growth as pollen grains staining dark blue with iodine before germination, give only light blue or yellow colouration with iodine after the tubes have attained a sufficient length. Further, pollen grains that appear full of contents under the microscope before emission of tubes, become transparent and appear as if emptied partly or completely of their contents when the tubes are sufficiently long. That sugar agar medium plays an important part in the promotion of the growth of the pollen tube is supported by the observations made on the pollen tubes produced without the aid of any external medium. Sugarcane pollen can be made to germinate to a fair extent by a careful regulation of moisture supply alone. A fair measure of success was obtained by the following methods :—

(1) In a petri dish provided with a wet blotting or filter paper in the bottom, is placed a glass ring covered with a cover slip. After five minutes

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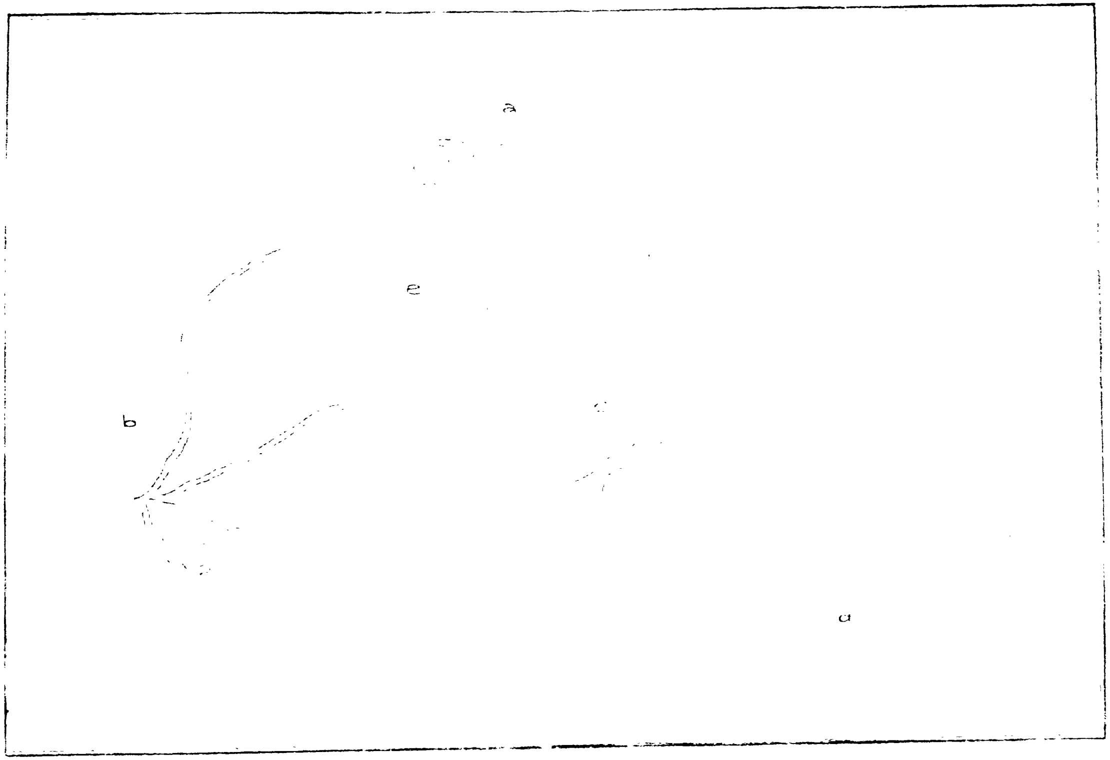
[1] *loc. cit.*
[2] *loc. cit.*

PLATE XVIII.



Branching of the pollen tubes grown in culture media.

(*a*) M. 55133. showing the tendency to branch.
(*b*) M. 55133 clear three branches, the main tube dividing a little further away from the grain.
(*c*) Saretha Devi. Tip of the pollen tube swollen.
(*d*) M. 55133. two long branches emerging from a common point on the grain.
(*e*) M. 55464. same as (*b*).

The above are photographs of camera lucida drawings under high power.

the cover slip is removed and the pollen dusted on the side exposed to moisture and the cover slip replaced in the original position.

(2) Pollen is dusted on a dry slide and a drop of water is placed by the side of the pollen grains. The whole is enclosed in a glass ring fixed to the slide with vaseline whose top is closed with a cover slip made air-tight with vaseline.

The pollen tubes produced in either of the above method have, so far, never been found to grow beyond a length of 300 μ and are further comparatively thin. The thinness and shortness of the pollen tubes produced with the aid of moisture alone strongly suggests that the sugar agar medium either provides direct nutrition to the growing tube or affords a favourable ground for the formation and subsequent assimilation of substances that aid the growth. The fact that other sugars, *viz.*, lactose, maltose, galactose, etc., did not prove fit media for germination, lends additional support to the view that sucrose acts in some way as a specific stimulant for germination of sugarcane pollen and subsequent growth of the tubes.

That the germination of cane pollen is not merely the effect of a balanced osmotic condition but the result of a response to a definite chemical stimulus in sucrose, seems a plausible explanation of the fact that solutions of maltose, lactose, dextrose, etc., isotonic in concentration with a 26 per cent. solution of sugar do not give satisfactory germinations. Further, the formation of tubes, though uncertain, under suitable conditions of moisture alone in the absence of any culture medium adds strength to the view that a balanced osmotic condition is not the only desideratum to the germination of cane pollen.

VI. Summary.

(1) Best germinations were obtained in 26 per cent. sucrose *plus* 0·7 per cent. agar culture medium. The moist chamber adopted was a glass ring 7·5 mm. high and 17 mm. in diameter covered by a cover glass containing dusted pollen on the culture medium. Two or three drops of the same culture medium at the bottom of the chamber were found to be most suitable as a source of moisture supply.

(2) Both thick and thin cane varieties together with Java, Coimbatore and other seedlings were tried and the percentages of germinations obtained varied. A maximum of 61 per cent. germination was obtained with M. 54111—a seedling evolved at the station.

(3) Germinations were obtained at temperatures ranging from 22° C. to 33° C.

(4) Cloudy weather was found to have no very harmful effect on the ultimate germinations. Pollen collected on a cloudy morning preceded by a cloudy and rainy night did give germinations.

(5) Pollen of Saretha Desi, a thin cane variety, was found to retain its viability for two hours when exposed to atmospheric conditions in the laboratory and for one hour when exposed to free air in direct sunlight.

Acknowledgments are due to Rao Bahadur T. S. VENKATRAMAN, B.A., I.A.S., Government Sugarcane Expert, for facilities afforded and to Mr. C. TADULINGAM, F.L.S., Principal, Agricultural College, Coimbatore, for kindly arranging to do the micro-photographs reproduced in the paper.

SELECTED ARTICLES

CO-OPERATIVE DEMONSTRATION TRAINS.*

INTRODUCTORY.

ONE of the greatest problems which has confronted India's administrators has been the imparting of education in scientific agriculture to her illiterate millions. In a country dependent for its existence and wealth upon its agricultural resources the need for the instruction of those occupied in primary production in improved methods, is obvious and cannot be disregarded. Government, through its Imperial and Provincial departments of Agriculture, has paved the way to a solution of the problem and at numerous centres, agricultural farms have been set up and the results of improved methods in cattle breeding, dairying and other important branches, practically demonstrated. Agricultural shows and fairs are held regularly in different parts of the country whereat much is done to enlighten the agriculturist visitors. Other methods of imparting knowledge have been introduced, but generally speaking, the full value of these measures to the State has not been obtained for the want of adequate publicity and propagandist facilities.

It is probable, therefore, that the two most recent innovations the 'TRAVELLING CINEMAS' and the 'DEMONSTRATION TRAINS' initiated by the Railway Department of the Government of India and involving active co-operation, with all its attendent advantages, between the departments interested, are destined to have the farthest reaching results in the broadcasting of agricultural science. The outstanding merits of these two forms of enlightenment are, firstly, that they cover an unlimited area, thereby establishing contact with the masses throughout the length and breadth of India, and secondly they make their appeal through ocular demonstration accompanied by lectures, thus bringing home their lesson very vividly to the vast crowds of interested and eager spectators who congregate to see them.

The Railway Board recently issued a memorandum explaining in detail their activities in connexion with travelling cinemas as well as their film production policy and in this note, therefore, it is proposed to deal only with the Demonstration Trains.

OBJECT OF DEMONSTRATION TRAINS.

The principal object of the Demonstration Trains is to provide a solution to the problem referred to in the introductory note, namely, the grounding of the

* Memorandum prepared by the Chief Publicity Officer, Railway Board.

illiterate primary producer, in the knowledge that the quality and quantity of his output can be markedly improved by the use of modern scientific methods. It has been felt too, that many of the valuable results attained by the department of Agriculture in the course of its researches have not been made sufficiently widely known owing to lack of publicity for this purpose. More especially, therefore, is an endeavour being made to demonstrate practically the methods in farming, cattle breeding and dairying, tested and proved successful in this country by the department of Agriculture, whose procedure and results are made available to those interested.

Simultaneously and in a like manner, the trains provide an opportunity utilised to the best advantage for spreading information and propaganda as well as practical demonstration in connexion with Public Health, Veterinary Science and the work of the Government Industries and Co-operative Departments. All these are actively engaged in an endeavour to promote improvement in their respective spheres, but the scope of their utility is limited by their disability to acquaint the masses with their activities and achievements and thus encourage interest and emulation.

Description of trains and cars.

The first Demonstration Train in India was introduced on the Eastern Bengal Railway last year. It comprised seven bogie Demonstration cars and additional carriages either bogies or four-wheel vehicles, to accommodate an officer-in-charge of the train, the attendant staff, the electric power, a motor lorry and a motor-car. The Demonstration cars originally consisted of 3rd class bogie carriages which were denuded of their ordinary internal fittings and then suitably converted and fitted out for display and educational purposes in accordance with the requirements of the particular department in whose service they were to be utilised. The departments of the Government of Bengal who cordially co-operated with the railway and shared in the expenditure involved in working the train which was based on actual cost were the Agricultural, Veterinary, Public Health, Industries and Co-operative departments and the Railway themselves provided publicity display, and an information bureau as well as light refreshment and catering compartments, the latter being managed by a contractor for the use of all the demonstration staff in attendance on the train. The following particulars of the arrangements made and of the displays provided in the respective cars on the train have been furnished by the Eastern Bengal authorities.

Agricultural car.

This Car was divided into two sections namely Sericulture and General. The exhibits included implements, samples of cereals, pulses, oil seeds, fibres, fodder and food stuffs for cattle : narcotics and drugs : typical soils of Bengal : manures and fertilisers : insect pests and fungus diseases of crops : insecticides and fungi-

cides: sprayers and fumigators and a model of an improved furnace for jaggery making.

Veterinary car.

A number of charts, pictorial and doggerel posters and photographs, etc., were displayed in this Car illustrating *inter alia* milk yield and average quantity available for human consumption per head per annum: paucity of pastoral land and necessity for growing fodder crop: common causes of degeneration of cattle in Bengal with practical remedy: common, contagious and infectious diseases and their remedy: proper and improper food for cattle: points of good cattle, etc. Other exhibits were a collection of different kinds of cattle fodder: poisonous and medical plants: pathological, biological and bacteriological specimens and instruments for veterinary treatment.

Public health.

The Public Health Car contained interesting models showing Malaria—its spread and prevention: work of anti-malarial societies: cholera, enteric and other waterborne disease—how they spread, and methods for their prevention with special reference to anti-cholera vaccine: small-pox and its prevention by vaccination: child welfares trained and untrained *dais*: good and bad lying-in-room: Food,—vitamin values of different food stuffs: actual and recommended diets.

Coloured posters were displayed illustrating the causes, prevention and cure of malaria, cholera, small-pox, tuberculosis, kala-azar and depicting various aspects of child welfare. A pictorial representation of the diets of different nationalities and their effect upon the human system was exhibited. The posters also included a series of "hygienic habits" pictures.

Industries car.

This Car was divided into two sections—Weaving and Tanning—each occupying half of the bogie carriage. The Weaving section was represented by a Government Weaving Institute. Practical demonstrations of improved methods of spinning, weaving, dyeing and printing of textiles were given both inside the car and outside on the platform. In addition to improved looms, etc., various charts and the textile products of the Government Weaving School were exhibited. Cane work and the making of useful household articles, including mattresses, also thatching, by utilising the common water hyacinth, were illustrated by actual demonstration as well as by exhibits and pictures. The Tanning section was represented by the Bengal Tanning Institute, Calcutta. The exhibits consisted of various kinds of leather and manufactured leather goods made at the Government Institute: tanning materials: defective hides due to bad flaying and ill feeding: warble holes goad marks: sore marks: skin diseases: vulture pecks: bad curing: thorn marks: branding marks; and instruction charts showing how to get rid of these defects.

CO-OPERATIVE CAR.

The Car of this Department was fitted up as an Information Bureau for all co-operative activities in the Presidency of Bengal. The activities, progress and achievements of the Department and the different kinds of Co-operative Societies at work in the Province, were indicated by means of photographs, models, charts, graphs and redeemed bonds and other displays. Officials of the Department explained the exhibits which were designed to show the benefit accruing from the application of co-operative principles in various directions such as improvement of the health of the people : improvement of cattle : organisation of credit : agriculture : industries : production and sale : purchase and sale : sale and supply and lastly social work. Textiles and various other products of industrial Co-operative Societies were also exhibited. The displays in this car were very artistically presented.

RAILWAY CAR.

The Publicity Car provided a display of posters, literature, time tables and photograph albums. Inquiries and information were dealt with by two clerks who accompanied the train for this purpose and those questions to which replies could not be furnished on the spot were registered for written replies to be given subsequently.

GENERAL.

The departments represented provided information and literature in the form of leaflets, books and photographs connected with various phases of their activities, and many cinema films, produced with the same object, were furnished by the respective departments including the railways, and were displayed by the Eastern Bengal Railway as an additional means of providing instruction to interested spectators. Several lecturers explained the various exhibits, answered questions and gave information to visitors.

ITINERARY.

The train visited thirty stations in Bengal covering a distance of 1,262 miles, in doing so, its arrival at each halting point being preceded by a keen publicity campaign. The patronage accorded and the interest taken throughout the tour were all that could be desired and it was estimated that about 90,000 people frequented the train and 1,20,000 were present at the cinema and lecture meetings held in the evenings in the neighbourhood of the halting station.

RESULT.

As a result of this patronage, enquiries were registered in the various cars, the Agricultural Department receiving more than five hundred, as well as indents for

improved seeds and manures. Great interest was taken in the Industries exhibits by visitors, amongst whom were a number of college students. The veterinary display resulted in considerable contributions of money and land in various places for the establishment of local veterinary hospitals and dispensaries. The tour, therefore, clearly demonstrated in a concrete manner that the train filled a definite need, and brought the various Government departments into direct touch with the people in whose interests they were working.

Four demonstration trains proposed.

As a direct result of this successful experiment, the Railway Board has decided to introduce a Co-operative Demonstration Train on all the four State Railways in the near future, and each railway administration in conjunction with the Local Governments concerned is now working towards this end. It is probable, in order to facilitate work and prevent overlap where two railways serve the same Province and avoid a double call on one Government's purse, that individual railways will restrict their tours to the portion of their system lying within particular specified Provinces and in this regard the programme under consideration is as shown below :—

Railway.	Province.
Eastern Bengal.	Bengal.
East Indian.	Bihar & Orissa and United Provinces.
North Western.	Punjab and Sind.
Great Indian Peninsula.	Bombay and Central Provinces.

Modification to suit local conditions.

The trains will be organised more or less on the lines of that of the Eastern Bengal Railway hereinbefore described with modifications to suit the requirements or peculiarities of those Provinces which they will particularly serve. When the equipment of the cars by the departments represented has been completed and an itinerary drawn up, the "Travelling Exhibitions" thus created, will leave the headquarters of their respective administrations, on tours extending probably over a period of two months. Demonstrations will be given at important centres ranging from 50 to 100 miles apart and halts for this purpose will probably be of two or three days' duration in order that an opportunity and sufficient time may be given for those of the people, who are resident at some distance from the railway line, to visit the trains.

Basis for charge—actual cost.

It has been remarked elsewhere that the expenditure involved in running these trains is shared by the Local Government departments making use of them, but that the charge levied is based on the actual cost of working only.

The Railway Department of the Government of India in introducing this departure does not desire to recover directly anything in excess of its working expenditure for the reason that apart from the immense benefit which must accrue to the State from the encouragement of this enterprise, a well organised campaign is certain to result in increased traffic and earnings.

Local Government co-operation. Success assured.

These proposals should materialise within the next few months and the keenest appreciation and closest co-operation is already forthcoming from the Local Government departments concerned. The prospects of a most successful campaign throughout the vast area served by the State Railways directed towards uplifting the masses and building up the welfare and wealth of the individual and the State, seem, therefore, assured.

DR. VAN HARREVELD'S IMPRESSIONS ON CUBA.

(TRANSLATED.)

THE "Indian Mercury" of the 29th June, 1927, published an interview with Mr. Ph. Van Harreveld telling of his impressions on Cuba, from which country he had just then returned. The impressions and conclusions of this world-famous sugar specialist are so important that we translate them hereunder *in extenso.*

GRINDING.

With regard to the milling work, Cuba, in so far as capacity is concerned, is decidedly in advance of Java, but crushing thereby must, of course, suffer. The rollers are of the same dimension as in Java, *viz.*, 36" × 84", but where in Java newly installed factories have one crusher and four rollers, and not long ago the factory "Beram" set the example of putting a battery of five rollers behind one crusher, in Cuba one can see many installations consisting of one crusher and seven rollers. There is, for instance, one Central grinding 70 million arobas * cane (14 million piculs) which in Java would require a planted area of 10,000 bouws. The best installed mills in Java which can grind large quantities are "Djatiroto" having three batteries of grinders each of 25,000 piculs, "Tjmal" with one battery grinding 28,000 piculs, and "Tjepiring" also with one battery grinding 26,500 piculs in 24 hours. In Cuba one battery grinds 48,000, 67,000, even 88,000 piculs in 24 hours, and the Central "Vertientes" obtained a record of 92,000 piculs with one set of cutters, one crusher and seven rollers, which installation was erected by Hoover, Owen and Rentschler of Hamilton, Ohio; and in due American style this accomplishment is made world-known on a board attached to one of the grinder standards bearing the inscription :—

"World's Record—467,608 arobas."

One who has seen the amounts of ampas (cane refuse) in front of the boilers of a Java Sugar mill, and the many hard labouring coolies who have to fill the even insatiable mouth of the fires would be surprised to see a photo of a Cuban boiler battery, as there everything is done automatically, and although work is in full swing not a labourer is to be seen. The feeding is done quite automatically, and high chimneys such as serve the motorist in Java as landmarks are totally absent in Cuba, because sufficient draught is derived from electric fans. The Babcock and Wilcox water tube boiler has here in Cuba completely replaced the former fire tube boiler. Waggons of 20 to 30 tons take the cane to the mills. They are pushed on a revolving base, and it needs only one man to manage the handle in order to

* 98 7/10 arobas = 1 ton.
1 picul = 136 lb.
1 bouw = 1·74 acres or 1¾ acres approximately.

shoot out the cane which falls into a very deep cavity from where it is transported by a carrier to the grinders. In Java this same work requires an army of men. Very often a set of cutters automatically arranges the feeding and the carrier which transports only a certain requisite quantity. Where labour in Cuba is so much better paid than in Java, it needs no comment that labour-saving devices are applied liberally. Cane discharging installations in Java, which are worked by electricity and which require a special dynamo working day and night, a special overseer and many coolies, cost a lot of money for installation, upkeep and depreciation. Quite apart from the question of labour-saving, I think that a good deal of money could be saved in Java by applying the cheaper Cuban method. This method will need an increase in rolling stock of a heavy type, and it will probably require fixed rails, but these expenses will certainly be less than those of the Java cane discharging installation.

As in Australia, South Africa and formerly in Java, cane is planted in Cuba under contract, and the so-called "colonos" (independent farmers) deliver their cane to the factory. Some of these colonos possess their own very extensive plantings and are really wealthy. Factories are owned by American and Cuban concerns, partially also by English and Spanish Companies, but American refiners can claim an important share.

ESSAY STATION.

The Cuban Sugar Club, founded on the 3rd May, 1922, publishes periodically during the campaign lists of milling and controlling, the same as is done in Java by the Pasoerœan Essay Station. In Java practically all the mills are associated with the Essay Station; this, however, is not the case in Cuba. The total number of mills in Cuba amounts to 177, about the same number as the factories in Java, but producing 2 to $2\frac{1}{2}$ times as much sugar as in Java, which shows that the capacity of each mill in Cuba is at least double that of Java's. Of these 177 mills only 85 (about 50%) are associated with the Sugar Club. The oldest Centrals are situated in West Cuba, and the soil there has been exhausted by predatory cultivation. It is here that the cyclone of October 1926 has done the worst damage. It is estimated that by this cyclone 200,000 tons of sugar was lost owing to broken and beaten-down cane. Cane planting in East Cuba was only commenced during the war. As was the case with Djatiroto, Java, woods were cut and on the soil, which was very rich, cane was planted, and it grows there far better than in the West.

In Cuba the cane is cut three to eight times to one sowing; exceptionally ten to twelve cuts are made. Irrigation is totally lacking, and everything is done on the Tegallan (dry plantations) system. Everyone can imagine the calamity of long lasting drought during the rainy season, as plantings are then bound to be ruined. This means the cut which is then growing, because if during the next season rains come through well, the same cane grows again marvellously, and the

next crop compensates for everything, provided prices are good enough; which proves that in a certain sense Cuba is a land of unlimited possibilities. Owing to the repeated cuts, the cane, generally speaking, is short, and the average length of the sticks which reach the mills is about 32".

Restriction.

Dr. Van Harreveld says that in Cuba sugar is the cork on which the whole island drifts. What grain is to Canada, banks and hostelries to Switzerland, cattle to Latin America, and coffee to Brazil, so sugar is to Cuba, and it, therefore, need surprise nobody that at the present moment not a soul in Cuba has a good word to say of the ill-famed restriction. The expected result did not materialize, but this is perhaps more in appearance than in reality. Cuba had dreamt golden dreams of restriction, but they did not come true. Without restriction the situation would have been much worse still, because then also owing to the Suzuki debacle, very low sugar prices would have resulted, with bad consequences to Cuba. If, in a time of over-production, unforeseen happenings, such as, for instance, this big Japanese failure, occur, they take such tremendous proportions that a panic is unavoidable. Every unfavourable news item is then used as material for the bears, and it then does not take much to see the bottom drop out of the market.

If one considers that Cuba during 1926 produced 4,800 tons, that the cyclone damaged about 200,000 tons, and that during 1927 about one to one and a half million tons of sugar was left uncut on the fields, the 1927 crop could then have been, without cyclone and without restriction, six to six and a half million tons. If such a large quantity had been on the market for sale at the time of the Suzuki difficulties, crisis would have been a dead certainty, the consequences of which would have been felt long after, as prices can fall far more quickly than they can be re-adjusted, as we have seen during 1920-21.

The Cuban trade is, therefore, unfair to blame President Machado for his Sugar Restriction Bill. Had he not signed it, things in Cuba might have been very bad indeed. It is difficult to guess what is going to happen in 1928. In Cuba[1] everything depends on the weather and prognostics are, therefore, impossible. There certainly is a surplus in cane of 1½ million tons of sugar, which remained on the fields and which can make its appearance during 1928. However, if the weather remains unfavourable, the 1928 crop may not be larger than during 1927, though, contrary to Java, cane does not deteriorate in Cuba by not cutting it, and this surplus of 1½ million tons of sugar always remains a factor with which the sugar world has to count.

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[1] Since this was written, weather conditions in Cuba have improved to such an extent that the crop is making a favourable growth (W. S.).

[The Cuban crop of 1928 has been restricted to 4,000,000 tons under the decree issued by the President of that republic. W. S.]

NOTES

SELECTION OF BURMA BEANS FOR LOW HCN CONTENT.

My attention has been drawn to an article in *Tropical Agriculture*, November 1927, Vol. IV, No. 11, page 207, *viz.*, " Plant Breeding " by J. B. Hutchinson, B.A., in which data from my paper " Selection of Burma Beans for low HCN content" (*Memoir of Department of Agriculture in India, Chemical Series*, Vol. IX, No. 1, 1926) is criticised from the botanical point of view.

It was known from the start, *i.e.*, about 1916 that selection of Burma beans would most probably result in no improvement as regards HCN content. Orders were to the effect that this should be actually demonstrated by practical experiment failing other satisfactory proof. I took over the work in February 1921 and merely carried out selection work from best individual plants to show that *Phaseolus lunatus* did not respond to selection for low HCN content. This is not clearly stated in my *Memoir of the Department of Agriculture in India, Chem. Ser.*, Vol. IX, No. 1, but it was never thought possible that the context of the memoir in question would have given rise to the idea that I believed that a HCN—free variety would be obtained by selection (other than a mutant). I may therefore quote the following to clear up the position :—

(1) *Annual report of the Agricultural Chemist, Burma, for the year ending 30th June, 1923.*

Page 4.—"Although much work on the occurrence of cyanogenetic glucosides in *Phaseolus lunatus*, etc., has been done, an extensive search has failed to show a published account of the results of the selection on HCN content. At the present time it cannot be stated that Burma beans respond to selection for low HCN content. No sustained attempt seems to have been made and since the question seemed to be an open one, the author commenced this work as early as possible, *viz.*, in 1921-22."

Had such a published account been available, and this is of course expecting the impossible, it would have been possible to have avoided carrying out a work which was regarded as hopeless from the start.

(2) *Annual report of the Agricultural Chemist, Burma, for the year ending 30th June, 1924.*

Page 5.—" Prussic acid is a normal character in *Phaseolus lunatus* and even a mutant were found containing no HCN, this mutant would be a bean of

a quite new type and would not be a *Phaseolus lunatus*. Not the least hope now exists that such a mutant will be found. Already considerably more than 3,000 individual plants have been examined and in every case HCN was found.

Unfortunately, the annual reports do not seem to have the same circulation as *Memoirs of the Department of Agriculture in India*, and whereas all workers in India were probably quite well aware of the real object of the work, unfortunately this does not appear to be the case elsewhere.

In brief, then, whereas it was from the start considered that HCN could not be eliminated from Burma beans by selection, the work had to be carried out to convince people without knowledge of plant breeding that selection within a pure line was futile. There was, of course, the chance of discovering a mutant. Had the advice of competent agriculturalists available been accepted, the work would not have been undertaken. Hence, to undertake such a work at all, it was necessary to assume that the impossible was possible in order to give the work the fairest possible trial in practice. [J. CHARLTON.]

PRODUCTION OF REFINED SUGAR FROM GUR IN INDIA IN 1926-27.

THERE were 29 concerns in India in the year 1926-27 capable of refining *gur* or raw sugar by modern methods. Out of those, five did not work during the season. Detailed figures for the season 1926-27 are awaited from 3 factories whose combined output in 1925-26 totalled :—

	Maunds
Gur or raw sugar melted	85,814
Sugar made	44,712
Molasses obtained	38,951

Returns have been received from 21 factories. Eleven out of the factories that have submitted their returns are situated in the United Provinces, 7 in Bihar, 2 in Madras and 1 in the Punjab.

It may be stated here that in 1925-26 nineteen factories submitted their returns, out of which 3 did not work this season while 3 more have not yet replied to our enquiry as reported above. It will thus be seen that out of the 21 factories that have submitted their returns for the season 1926-27, thirteen are old ones and the remaining 8 undertook refining operations either for the first time or after discontinuing in the previous season.

The figures of *gur* or raw sugar melted, sugar made and molasses obtained in the whole of India during the season 1926-27 are given below. The figures for the concerns in the United Provinces, Bihar, and Madras and the Punjab are also given separately for the information of those interested

Total for the United Provinces.

—	1926-27	1925-26
	Maunds	Maunds
Gur melted	18,52,314	10,87,827
Sugar made	8,93,652	5,32,335
Molasses obtained	7,67,734	4,42,015

Total for Bihar and Orissa.

—	1926-27	1925-26
	Maunds	Maunds
Gur melted	6,36,743	2,08,907
Sugar made	3,23,639	98,830
Molasses obtained	2,50,678	83,673

Total for Madras and the Punjab.

—	1926-27	1925-26
	Maunds	Maunds
Gur or raw sugar melted	5,77,842	7,15,194
Sugar made	3,66,706	4,16,255
Molasses obtained	1,59,619	2,15,796

Grand total for India.

—	1926-27	1925-26
	Maunds	Maunds
Gur melted	30,66,899	20,11,928
Sugar made	15,83,997	10,47,420
Molasses obtained	11,78,031	7,41,484

A note published in the *Agricultural Journal of India*, Vol. XXIII, Part 1 (1928) gives the total quantity of sugar produced by factories making sugar direct from cane for the two seasons 1926-27 and 1925-26 as follows :—

	Maunds	Tons
1926-27	17,16,426 or	62,941
1925-26	14,45,061 or	52,990

If the quantity of sugar refined from *gur* or raw sugar in India by modern processes during these seasons be added to the above figures, the total production will amount to 33,00,423 maunds or 121,028 tons in 1926-27 as compared with 24,92,481 maunds or 91,499 tons in 1925-26.

A table is given below showing the production of sugar direct from cane and from refining *gur* or raw sugar during the last eight seasons.

Production of sugar.

—	Direct from cane	Refined from *gur*	Total
	Maunds	Maunds	Maunds
1919-20	6,28,920	12,11,274	18,40,194
1920-21	6,69,291	13,24,646	19,93,937
1921-22	7,53,638	13,03,433	20,57,071
1922-23	6,51,415	13,68,126	20,19,541
1923-24	10,44,856	15,38,304	25,83,160
1924-25	9,21,950	9,16,121	18,38,071
1925-26	14,45,061	10,47,420	24,92,481
1926-27	17,16,426	15,83,997	33,00,423

It will be seen that the quantity of sugar refined from *gur* in 1926-27 shows roughly an increase of 50 per cent. over the previous year. This is due to the fact that some of the factories making sugar direct from cane also worked as refineries during the off season, with a view to reduce their silent overhead charges. The average price of refining *gur* in January 1927 was Rs. 5 per maund at Cawnpore, and the average price of Java white sugar and Indian factory made sugar from *gur*, *viz.*, Cawnpore Special Sugar, in the same market was Rs. 13-14 and Rs. 13-1 per maund. The margin then appeared sufficient to make *gur* refining profitable. But it so happened that the prices of sugar declined during the year and many of the refineries must have found this business hardly remunerative.

In conclusion, the writer wishes to express his obligations to the Managing Agents, Proprietors, and Managers of the various concerns for kindly furnishing the figures worked up in this note. [WYNNE SAYER.]

WORK OF THE GENETICS DEPARTMENT OF THE EMPIRE COTTON GROWING CORPORATION'S RESEARCH STATION IN TRINIDAD.

We have received the following extract from the Secretary, Indian Central Cotton Committee, for publication :—

DR. S. C. HARLAND, the principal of the above, delivered a very informative address at the sixth Annual General Meeting of the Corporation. The lecturer was most particular in making every detail of his scientific subject clear in the ordinary language of the business man, and this exceptional fact undoubtedly contributed largely towards the appreciation with which the address was received. Dr. Harland said :

"Perhaps I had better begin by giving as clear a definition as I can of what 'genetics' is, and afterwards continue by telling you a little of what it has been possible to do with cotton. Genetics is the science which deals with hereditary factors both in plants and animals. The science is comparatively new. It is only within the last 30 years that we have got to know very much about it, but particularly during the last fifteen years an enormous amount of information has been obtained about inheritance in plants and animals; and the facts which have been accumulated are proving of the very greatest importance in their relation to such things as improving the yield and quality of many crops. If you take the cotton plant you are face to face, first of all, with the fact that cotton exists in a tremendous number of different varieties and species. Some of these have never been under cultivation at all. There is a species which is found growing wild in Hawaii on the slopes of one of the volcanoes there which exists only as a group of scattered plants occupying an area of about 100 square yards. Then you have the wild cotton which comes from Polynesia, and the wild cotton which grows in some of the islands off lower California, and you have other types from mountains of Central India and Upper Burma. There is a huge, practically unexplored field of the species of *Gossypium* that has never yet been exploited. One of our first tasks was to get together as complete a collection as possible of every species and variety of cotton which exists, to grow them all, and to note accurately the characteristics which they displayed. The varieties of cotton which are under cultivation at present are, in our view, only more or less chance selections that people have made from a huge welter of different types, and we regard it as conceivable that among the unstudied forms in various parts of the world we may drop across something which is very much better from some points of view than the types now grown. That is, we regard it as a pity not to take advantage of the very wide variability existing in the genus *Gossypium* to which cotton belongs. Much useful information has already been obtained. Many of you, probably all

of you, are aware of the fundamental difference which exists between the very short staple Indian cotton and the ordinary American cotton which is largely used in Lancashire. The Indian cotton is very short and coarse and can only be used for very low counts. But at the same time it is well known that Indian cotton is exceedingly hardy. It will grow where other cottons either will not grow at all or grow only with difficulty. There is a huge area in India known as the black cotton soil of India, which is so called not because the soil is good for growing cotton but simply because the soil is so bad that cotton is almost the only plant which is an economic crop. As I say, these very short staple types are most remarkably hardy. They will resist drought and insect pests, and we thought that if we could make a survey of the whole group we might come across something which, by selection, could be improved and probably be brought up to the standard of the ordinary American cotton. If we could do that, we should probably be able to introduce this new type of cotton into areas where the ordinary American cotton will not grow. It is rather interesting that among the types we collected was one from Upper Burma, near Mandalay, that was grown by the natives of the Shan States. This cotton was regarded as a very fine cotton, although it existed in very small quantities. We got some of the seed, and we have found it retains its very long silky staple. The staple runs up to about $1\frac{3}{16}$ in., equal to ordinary long-staple Upland. We have crossed it with Chinese cotton known as the 'Million Dollar' cotton, which is a very high yielding type, and we have now got some new strains which we hope will be ready for testing two years hence, as soon as we got a sufficient quantity. We are very much impressed by the merits of these new cottons. It is perfectly conceivable that all the American cotton which is grown in South and sub-tropical Africa will sooner or later be replaced by new types of long-staple Indian cotton, which are very much more drought-resisting than the American type, and stand up to a very wide variety of conditions. That is one kind of investigation which is being carried out.

Then there is another point which may be mentioned. A good many of the cottons which have been grown are very susceptible to the attacks of certain insects and diseases. In the Sudan there is a disease called black-arm, which is a very virulent disease which does a tremendous amount of damage, particularly to Egyptian cotton. It not only succeeds very often in killing the plant, but also attacks the bolls and depreciates the quality of the staple. We have in Trinidad several types of cotton which are almost immune to this particular disease, and we are building up a collection of types immune to black-arm disease for distribution in various parts of the world and for testing out in comparison with the types which are grown there. It is hoped that this will be a very profitable line of investigation.

Then there is another point that may be emphasized. Although we were told when we first took up our work that we were not bound to undertake any work of immediate economic application, but were to find out as much as possible about

the cotton plant, we have in our own department taken up the point of view that there are certain problems of urgent economic importance which we can tackle even with our present state of knowledge. One of our main problems is the question of neppy cotton, its cause, and, if possible, its cure. One of the chief complaints about certain types of Empire cotton is that they are neppy, and the same complaint is made about certain types of Egyptian cotton. I believe Sakel cotton is very much more neppy than the old Joannovitch cotton, which was remarkably good in that respect. We have been going into this question of nep, and have made the interesting discovery that there are certain Mendelian hereditary factors which can cause the death of seeds inside the fruit or boll when the seeds are a quarter or half grown. Imagine a seed growing in a boll. The cotton attains its full length and begins to put on a certain amount of thickening ; it begins to ripen up. Then the seed dies. Of course, the cotton from those dead seeds is weak, is thin-walled, and when it is spun it causes neps. It gives a very great deal of trouble. We have established quite clearly that these seeds can be killed through the operation of certain hereditary factors, and that by selection we can reduce the proportion of dead seeds to an almost infinitesimal amount. Some of the American-Egyptian cotton that we have tested gave up to 25 or 30 per cent. of dead seeds, and an examination of the cotton from those seeds showed that it was just of the character which would produce neps. By selection we have now got two or three types which show less than 4 per cent. of these dead seeds. Of course, you will realize that in a boll where you have between 20 and 30 and sometimes up to 40 seeds there must be competition between those seeds for water for and for nutrients of various kinds, salts and sugars, and if the conditions under which the plants are growing create very stringent competition between the seeds, very often it will result in the death of some of them. The latter may be farther removed from the source of nutrition than some of the others, and they may die from that cause. But undoubtedly one of the main causes of nep can be removed by selection, and is due to distinct hereditary factors.

In addition to the primary economic work, we have got together a collection now of nearly 400 different types of cotton. We have five assistants who have been trained in recording every possible measurable character of these varieties. A huge number of different crosses have been made between them, and the purely scientific work of investigating the mode of inheritance of many characters is being rapidly proceeded with.

It is necessary to explain why work on such a thing as the colour of the flower or the colour of the pollen or other of these apparently unimportant characters is of value. It is a little difficult to explain, but it is of value, because very often an economic character such as the quality of the staple is linked or is inherited together with some unimportant structural feature. So by studying the inheritance of flower colour you may be able to get at the inheritance of some staple quality which is extraordinarily difficult to work out by itself; that is, the colour

of the flower may be an index of some deep-seated pecularity of staple. We have found, for example, that in Sea Island cotton, the white-flowered forms always have very much coarser and shorter staple than the yellow flowered forms. Very often you can walk through a field and see white-flowered plants dotted about, and they are invariably borne on inferior plants. If we know the method of inheritance of the flower colour we are enabled very often to eliminate inferior plants in the crop before much flowering has taken place, thus preventing contamination of the whole crop with inferior types.

As a second example, I mention the colour of the pollen. In American cotton the pollen is white ; in Sea Island and Egyptian cotton the pollen is yellow. We have found that the white pollen types almost invariably give a heavier yield than the yellow pollen types. The reason seems to be that the pollen colour is linked with or associated in some way with the number of divisions in the boll. There are various types of boll, some having three divisions, some four divisions and some five divisions. The white pollen forms usually have four or five divisions and the yellow pollen forms usually have only three ; so that if you selected for white pollen plants out of some strains, you would be selecting automatically for a great number of divisions in the boll. You will appreciate, therefore, from the two examples I have given, that work on apparently such unimportant things as the colour of the flower and of the pollen is not altogether wasted, because it is associated in a very deep and intimate way with the qualities that you want for special purposes."
[Extract from the *International Cotton Bulletin*, Vol. V, 4 No. 20, July, 1927.]

SULPHURIC ACID TREATMENT OF COTTON SEED.

The Secretary, Indian Central Cotton Committee, has sent the following extract for publication :—

R. G. Archibald, Director of the Wellcome Tropical Research Laboratories, Khartoum, has published recently a report on the effect of the sulphuric acid treatment of cotton seed.

In recent years, the sulphuric acid treatment of cotton seed has been advocated as a preventive measure for certain diseases attacking cotton, notably the bacterial disease known as angular leaf spot, black arm, or boll rot, and the fungal disease known as anthranenose.

Experiments were carried out to test the effect of sulphuric acid treatment on the germination of cotton seed.

Seed treated in the proportion of 500 grm. to 100 c. c. concentrated sulphuric acid, washed for 10 minutes in 2 litres of water, dried, and then sown, yielded 95 per cent. germination.

Seed treated in such a manner and stored for 6 months gave 92 per cent. germination.

Seed treated with concentrated sulphuric acid for longer periods than one hour, or washed for longer periods than one hour after treatment, was adversely affected as regards germination.

Field observations on treated and untreated seed showed germination and plant growth in favour of the former.

Sulphuric acid treatment will not completely sterilize black arm infected seed, but appears beneficial because it delays the manifestations of the disease in the cotton plant. [Extract from the *International Cotton Bulletin*, Vol. V, 4 No. 20, July, 1927.]

BLACK ARM DISEASE OF COTTON.

The Secretary, Indian Central Cotton Committee, has sent the following extract for publication :—

R. G. ARCHIBALD, Director of the Wellcome Tropical Research Laboratories, Khartoum, has issued the results of his investigations in this disease. He arrives at the following conclusions :—

(1) Investigations have shown that, in black arm disease of cotton, the casual organism can be recovered from the tissues within the seed coat.

(2) A technique is described for recovering the bacillus from the seed tissues.

(3) The feeble resisting powers of the organism toward such adverse conditions as strong sunlight, desiccation, and high temperature render it unlikely that the outer coat of the seed, with its lint and fuz, harbours infection.

(4) The bacillus can be recovered from apparently healthy tissues below the black arm lesions.

(5) The seed appears to be the main source of infection.

(6) The casual organism has not been found in soil or water, and the epidemiology of the diseases does not favour the hypothesis that the disease is insect borne.

(7) No hosts other than the cotton plant have been found.

(8) Seed sterilization by means of concentrated sulphuric acid has yielded disappointing results. A more effectual way of attacking the problem is to ascertain the factors that predispose to manifestations of infection, and to raise a healthy type of plant capableof resisting as well as of throwing off infection when attacked [Extract from the *International Cotton Bulletin*, Vol. V, 4 No. 20, July 1927.]

COTTON NOTES.

Through the courtesy of the British Cotton Industry Research Association, the Secretary of the Indian Central Cotton Committee has sent the following abstracts for publication :—

Cultivation of Acala cotton in California.

The development of the one-variety community in the Coachella Valley of California from a mixed variety condition, and the procedure of establishing and maintaining a seed supply is described. [*U S. D. A. Bull.* No. 1467, 47 pp. (H. G. McKeever).]

Cultivation of Egyptian cotton.

A review of the commercial history of the Egyptian crop, dealing with the origin and development of several types and the danger of " Hindi " cotton. [*Int. Cotton Congress Rept.*, Egypt., 1927, pp. 82—88. Amin Yehia Pacha.]

A review of the costs of production. [*Int. Cotton Congress Rept.*, Egypt., 1927, pp. 88—96. Victor Mosseri.]

Cultivation of Maarad cotton in Egypt.

Particulars are given of the origin of Maarad cotton and the work done by the Royal Agricultural Society of Egypt to foster it. The crop this year should reach about 7,000 bales of 700 lb. [*Int. Cotton Congress Rept.*, Egypt., 1927, p. 59—61. Victor Mosseri.]

Effect of soil temperature on angular leaf-spot disease.

The development of the bacterial disease of cotton caused by *Pseudomonas malvacearum* in the seedling stage is confined to a definite range of soil temperature. At soil temperatures of 11—15°C. infection is low and in the case of lightly infected seed may be missed. From 16—20°C. infection is generally obtained, but is not usually serious if other environmental conditions are favourable for the growth of the seedling. From 21—26°C. infection is severe, from 26—28°C. it again fades in intensity, above 28° C. little or no infection is obtained and at 30°C. the plant is generally immune. Experimental evidence suggests that the regional distribution of the disease may be explained on these grounds. Some account is given of the internal changes associated with varying temperatures, and indirect support is given to Faulwetter's work on the spread of the disease in the field by rain. [*Ann. Bot.*, 1927, *41*, 497—507. (R. E. Massey).]

Cause of cotton wilt disease.

The cotton wilt organism, *Fusarium vasinfectum*, was isolated from strongly surface-sterilised cotton seed, indicating that the organism is at times carried on

the inside of the seed coat. The pathogenicity of the organism was proved by inoculation experiments. Artificially inoculated seed carried the viable organism on the seed lint for at least five months. The wilt disease was introduced into wilt-free soil by means of artificially infected seed. It is recommended that badly infected fields be rejected as a source of seed for planting. [*Jour. Agric. Res.*, 1923, *23*, 387—393. (J. A. ELLIOTT.)]

RESISTANCE TO WILT OF EGYPTIAN COTTON.

The percentage of seedlings which wilted in soil heavily infected with *Fusarium* were :—Sakel 96, Maarad about 80, Balls's "310" 73, Assili 54, Abbassi 26, Afifi 20, Pilion 13; Ashmouni and Zagora were immune. [*Int. Cotton Congress Rept.*, Egypt., 1927, p. 42—43. (TEWFIK EFFENDI FAHMY.)]

SUMMER IRRIGATION ON PIMA COTTON.

Experiments have been made to determine the effects of different frequencies of irrigation during the months of July and August on Pima cotton that had reached a normal early fruiting stage. It was determined that the different frequencies of irrigation did not cause any consistent significant difference in the growth of the plants, or in the yields. The experiment indicates the importance of giving more attention to the spring treatment of cotton, so as to have the plants in a normal fruiting condition when summer irrigation begins. [*Jour. Agric. Research*, 1923, *23*, 927—946. R. D. MARTIN and H. F. LOOMIS.]

GENETICS OF COTTON PLANT.

The author outlines the work of the genetics department of the Trinidad cotton research station. A collection which has been made of species and varieties of cotton from all over the world includes *Gossypium tomentosum*, *G. Stocksii*, *G. Davidsonii*, and *G. Sturtii*, wild cottons from Polynesia, India, Lower California, and Australia respectively. [*Empire Cotton Growing Rev.*, 1927, *4*, 325—329. S. C. HARLAND.]

PHYSIOLOGY OF COTTON PLANT.

During the past year three problems, namely, the shedding of flower buds and young bolls, variations in form and development of the plants as result of climatic and other causes, and the condensation of sugar to form cellulose in the lint hair, thus thickening the hair into a definite fibre, have been considered in the physiology department of the Trinidad cotton research station. The results so far obtained are briefly summarised, but it is hoped shortly to publish a paper giving a full account of the work. [*Empire Cotton Growing Rev.*, 1927, *4*, 330—336. T. G. MASON and E. J. MASKELL.]

Development of raw cotton in U. S. A. (North Carolina).

A report on cotton research in North Carolina. Storage of seed cotton from October, 2nd, 1925, to February 23rd 1926. did not change the weight, ash, or moisture content of the fibre, nor were the grade and staple influenced. A slight increase in strength was indicated, but when converted into yarn strength, the increase was very small. Other researches dealt with the inheritance of the fuzzy seed coat of cotton and its relation to lint production, hair distribution on the seedcoat of cotton, the relation of the percentage of undeveloped hairs to their position on the seed cotton, to the location of seeds in the lock, and to the location of bolls on the plant, and efficient nitrogen carriers for cotton. [*Expt. Sta. Rec.*, 1927, 57 228; from *North Carolina Sta. Rept., 1926, 14, 15, 21—28.* C. B. Williams, R. Y. Winters, *et, al.*]

Description of Egyptian cottons.

A series of notes on three varieties of lower Egypt, Domains Sakel,' 310,' and Nahda, and two varieties of Upper Egypt, Zagora Malaki and Ashmouni Malaki. Domains Sakel is the purest type of Sakel cotton existing in Egypt and has been developed by selection from the original Sakel of the State Domains. The variety 310 was produced by Balls and is an excellent spinning cotton. Nahda cotton is a derivative of the old Assili variety. Zagora Malaki is the best of the Zagora types and is superior to Ashmouni. It is the best cotton of Upper Egypt. Ashmouni Malaki is the best of the Ashmouni varieties. It has a very high yield and is particularly suitable for the south of Upper Egypt. [*Rev. Agric. Egyptienne*, Special number, March, 1926, 74—76.]

Thinning of cotton plants.

A preliminary account is given of experiments on the effect of time of thinning on the early development of the seedling during periods of water stress. [*Empire Cotton Growing Rev.*, 1927, *4*, 344—351. F. S. Parsons.]

Description of cotton fungus pest.

An account is given of a species of *Capnodium* which in 1925 was found to cause brown specks on the under side of leaves and on the bolls of Sea Island, American, and Indian local (*Desi*) varieties of cotton grown in the Botanical Gardens of Lahore. On both organs the infection appeared to have originated in the nectar glands. The fungus is dangerous in that it lowers the vitality of the host and renders it susceptible to the attacks of other organisms. It also lowers the quality of the lint in the attacked bolls. [*Rev. Appld. Mycol.*, 1927, *6*, 550; from *Jour. Ind. Bot. Sci.*, 1927, *5*, 141—186. A. Sawhney.]

Personal Notes, Appointments and Transfers, Meetings and Conferences, etc.

THE Department of Education, Health and Lands notification dated the 12th November, 1927, placing the services of Mr. G. S. Henderson, Imperial Agriculturist at the disposal of the Foreign and Political Department with effect from the 16th November, 1927, has been cancelled.

MR. J. R. HADDOW, B.Sc., M.R.C.V.S., D.V.S.M., Third Veterinary Research Officer, Muktesar, has been granted leave on average pay for eight months with effect from the 23rd April, 1928, or any subsequent date from which he may avail himself of it.

THE Punjab Government (Ministry of Agriculture) have created with effect from the afternoon of the 12th January, 1928, a seventh Agricultural Circle in the Province, comprising the districts of Simla, Kangra, Hoshiarpur, Jullundar and Ludhiana, with Head quarters at Jullundar.

KHAN BAHADUR MAULVI FATEH-UD-DIN, I.A.S., Deputy Director of Agriculture, Punjab, has been posted to the Seventh (Jullundar) Circle, and appointed officer on special duty in connection with the improvement of the sugarcane crop and the promotion of sugar factories. He assumed charge of his duties at Lahore on the afternoon of the 12th January, 1928, on recall from leave granted to him.

SARDAR SANTOKH SINGH, Superintendent, Cattle Farm, Nili Bar Colony, Punjab, has been appointed on probation for 2 years with effect from 16th January, 1928, forenoon against a special temporary gazetted post and placed under training at the Government Cattle Farm, Hissar.

SHEIKH MAHBUB ILAHI has been appointed Second Agricultural Engineer to Government, Punjab, Lyallpur, on probation for two years.

MR. A. C. EDMONDS, Deputy Director of Agriculture, I Circle, Madras Presidency, has been granted leave from 17th April, 1928, for 3 months on average pay and in continuation thereof leave for 4 months on half average pay.

DR. A. E. PARR, Deputy Director of Agriculture, Western Circle, Aligarh, has been granted leave on average pay for six months from 10th April, 1928.

MR. E. A. H. CHURCHIL, B.SC. (Edin.), Assistant Director of Agriculture, Chindwara, Central Provinces, has been appointed to officiate as Deputy Director of Agriculture, Northern Circle, Jubbulpore, *vice* Mr. Ritchie, on other duty.

MR. J. H. RITCHIE, M.A., B.Sc., has been appointed Secretary, Indian Central Cotton Committee, Bombay, *vice* MR. B. C. BURT, on other duty.

MR. G. C. SHERRAD, B.A. ,has resigned with effect from the 3rd February, 1928, his appointment in the Indian Agricultural Service.

DR. J. N. SEN, Bio-chemist at the Forest Research Institute, Dehra Dun, reverted to the Agricultural Department with effect from the afternoon of the 31st March, 1928.

MR. A. C. DOBBS, Director of Agriculture, Bihar and Orissa, has been granted leave for one year, six months and 22 days, *viz.*, leave on average pay for 8 months and on half average pay for the remaining period, with effect from the 12th April, 1928.

MR. B. C. BURT, M.B.E., B.SC., I.A.S., has been appointed to act as Director of Agriculture, Bihar and Orissa, with effect from the 12th April, 1928, during the absence, on leave, of MR. A. C. DOBBS.

REVIEW

The Patna College Chanakya Society has successfully completed the 18th year of its existence. During the period covered by its Fourteenth Annual Report (1926-27), the Society has continued to do fairly good work in the direction of studying the social and economic conditions of Bihar. Seven family budgets, two village surveys, two reports on co-operative societies, eight reports on industrial concerns and one co-operative survey, this last being a systematic and competent survey of co-operation in the Jamui Sub-division, were read before the society and discussed in its ordinary meetings. The Society also arranged for four expeditions to places of industrial importance in the province, to collect first-hand materials about industrial enterprise or decay. It can do much more than it has done. The Society expects now to widen the scope of its activities in the near future, and for this purpose wants to enlist the sympathy of enlightened public opinion and establish working connection with the Government departments of Bihar which are directly concerned with the economic life of the people.

NEW BOOKS

On Agriculture and Allied Subjects.

1. The Land of the Five Rivers, by Hugh Kennedy Trevaskis, I.C.S. Oxford University Press. Price, Rs. 9.
2. The following publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Memoirs.

1. Fruit-rot disease of cultivated cucurbitaceæ caused by *Pythium aphanidermatum* (Eds.) Fitz., by M. Mitra, M.Sc., F.L.S., and L. S. Subramaniam, F.L.S. (Botanical Series, Vol. XV, No. 3.) Price, As. 6 or 8*d*.
2. Colour Inheritance in Rice, by S. K. Mitra, M.S., Ph.D., and S. N. Gupta and P. M. Ganguli. (Botanical Series, Vol. XV, No. 4.) Price, As. 6 or 8*d*.
3. *Asterina* spp. from India, by Dr. Ruth Ryan ; *Meliola* spp. from India and one from Malay, by Prof. F. L. Stevens. (Botanical Series, Vol. XV, No. 5.) Price, As. 4 or 5*d*.
4. A contribution to our knowledge of South Indian Braconidæ. Part I. Vipioninæ, by T. V. Ramakrishna Ayyar, B.A., Ph.D., F.Z.S. (Entomological Series, Vol. X, No. 3.) Price, As. 14 or 1*s*. 3*d*.
5. The use of Hydrocyanic Acid Gas for the Fumigation of American Cotton on Import into India, by A. James Turner, M.A., B.Sc., and D. L. Sen, M.Sc. Tech., M.Sc., A.I.C. (Entomological Series, Vol. X, No. 5.) Price, Rs. 2 or 3*s*. 9*d*.

Books.

6. Some Diseases of Cattle in India : A handbook for stock-owners. Revised by J. T. Edwards, D.Sc. (London), M.R.C.V.S., Director, Imperial Institute of Veterinary Research, Muktesar. Price, Re. 1-4 or 2*s*.

List of Agricultural Publications in India from 1st August, 1927, to 31st January, 1928.

No.	Title	Author	Where published
	GENERAL AGRICULTURE.		
1	The *Agricultural Journal of India*, Vol. XXII, Parts V and VI and Vol. XXIII, Part I. Price, Re. 1-8 or 2*s*. per part. Annual subscription, Rs. 6 or 9*s*. 6*d*.	Edited by the Agricultural Adviser to the Government of India.	Government of India, Central Publication Branch, Calcutta.
2	The *Journal of the Central Bureau for Animal Husbandry and Dairying in India*, Vol. I, Parts III and IV. Annual subscription, Rs. 2-8, Single copy As. 10.	Ditto.	Ditto.
3	Scientific Reports of the Agricultural Research Institute, Pusa, (including the Reports of the Imperial Dairy Expert, Physiological Chemist, Government Sugarcane Expert and Secretary, Sugar Bureau) for the year 1926-27. Price, Re. 1-14 or 3*s*. 3*d*.	Issued by the Agricultural Research Institute, Pusa.	Ditto.
4	How to use crab traps in paddy fields. Madras Department of Agriculture leaflet No. 47.	R. Venkatraman, Assistant Paddy Specialist.	Government Press, Madras.
5	A note on the Anakapalle Experiment Station, Vizagapatam district. Madras Department of Agriculture Leaflet No. 48.	Issued by the Department of Agriculture, Madras.	Ditto.
6	Note to assist identification of Karunganni and Uppam Cottons. Madras Department of Agriculture Leaflet No. 49.	Ditto.	Ditto.
7	History of certain crops from sowing to harvest and describing their vicissitudes under adverse seasonal conditions. Madras Department of Agriculture Bulletin No. 88.	Ditto.	Ditto.
8	Villagers' Calendar, 1928 . .	Ditto.	Ditto.

No.	Title	Author	Where published
	General Agriculture—contd.		
9	Sugarcane mills and small power crushers in the Bombay Presidency. Bombay Department of Agriculture Bulletin No. 139 of 1927. Price, 0-6-6.	Rao Bahadur P. C. Patil .	Yeravda Prison Press, Yeravda.
10	Tobacco cultivation in the Southern Maratha country. Bombay Department of Agriculture Bulletin No. 140 of 1927. Price, As. 3.	S. S. Salimath.	Ditto.
11	Trees and Shrubs for producing green manure in the Konkan and North Kanara. Bombay Department of Agriculture Bulletin No. 141 of 1927. Price, As. 3.	V. G. Gokhale and V. S. Habbu.	Ditto.
12	Dry Farming methods in the Deccan. Bombay Department of Agriculture Bulletin No. 142 of 1927. Price, 0-6-9.	V. A. Tamhane, N. V. Kanitkar and G. M. Bapat	Ditto.
13	Experiments on Cotton manuring in Khandesh. Bombay Department of Agriculture Bulletin No. 143 of 1927. Price, 0-1-3.	K. M. Pawar and N. G. Apte.	Ditto.
14	The origin, plan and progress of the Sakrand Agricultural Research Station, Sind. Bombay Department of Agriculture Bulletin No. 145 of 1927. Price, 0-4-3.	Dr. Harold H. Mann.	Ditto.
15	Rice. Bengal Department of Agriculture Leaflet No. 2 of 1927 (in English and Bengali).	R. S. Finlow, B. Sc., Director of Agriculture, Bengal.	Sreenath Press, Dacca.
16	Cultivation of Potatoes. Bengal Department of Agriculture Leaflet No. 3 of 1927.	Ditto.	Ditto.
17	The Cultivation of Sugarcane. Bengal Department of Agriculture Leaflet No. 4 of 1927.	Ditto.	Ditto.
18	The Cultivation of Country Tobacco (in English and Bengali). Bengal Department of Agriculture Leaflet No. 5 of 1927.	Ditto.	Ditto.
19	The Manufacture of *Gur* from Sugarcane. Bengal Department of Agriculture Leaflet No. 6 of 1927.	Ditto.	Ditto.

No.	Title	Author	Where published
	General Agriculture—contd.		
20	A Japanese Millet : a fodder crop. Bengal Department of Agriculture Leaflet No. 7 of 1927.	R. S. Finlow, B.Sc., Director of Agriculture, Bengal.	Sreenath Press, Dacca.
21	Annual Report of the Department of Agriculture, Bihar and Orissa for 1926-27.	Issued by the Department of Agriculture, Bihar and Orissa.	Government Printing, Bihar and Orissa, Gulzarbagh.
22	Agricultural Statistics of the Department of Agriculture, Bihar and Orissa, for 1926-27.	Ditto.	Ditto.
23	Comments on the return of expenditure on the Provincial and District Gardens in the Central Provinces and Berar for the year ending 31st March, 1927. Price, As. 7.	F. J. Plymen, Director of Agriculture, Central Provinces.	Government Press, Nagpur.
24	The Cultivation of Groundnut. Central Provinces Department of Agriculture Bulletin No. 22, Price, As. 2.	W. Youngman and D. L. Janoria.	Ditto.
25	Annual Report on the Administration of the Department of Agriculture, United Provinces, for the year ending 30th June, 1927.	Issued by the Department of Agriculture, United Provinces.	Government Press, Allahabad.
26	Report on the Agricultural Stations of Central Circle, Cawnpore, United Provinces, for the year ending 30th June, 1927.	Ditto.	Ditto.
27	Report on the Agricultural Stations of Western Circle, United Provinces, for the year ending 30th June, 1927.	Ditto.	Ditto.
28	Combined Report on the Experimental Stations in the Eastern Circle, Partabgarh, United Provinces, for the year ending 31st May, 1927.	Ditto.	Ditto.
29	Report on the Agricultural Stations of the North-Eastern Circle, United Provinces, for the year ending 30th June, 1927.	Ditto.	Ditto.
30	Report on the Agricultural Stations in the Rohilkhand Circle, Shahjahanpur, United Provinces, for the year ending 30th June, 1927.	Ditto.	Ditto.

No.	Title	Author	Where published
	General Agriculture—contd.		
31	Report on the Agricultural Stations in the Bundelkhand Circle, Jhansi, United Provinces, for the year ending 30th June, 1927.	Issued by the Department of Agriculture, United Provinces.	Government Press, Allahabad.
32	Report on the Working and Administration of the United Provinces Government Gardens for the year ending 30th June, 1927.	Ditto.	Ditto.
33	Report on the Operations of the Department of Agriculture, Burma, for the year ending 30th June, 1927.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
34	Annual Report of the Yawnghwe (South Shan States) Agricultural Station, Burma, for the year ended 30th June, 1927.	Ditto.	Ditto.
35	Annual Report of the Myaungmya Agricultural Station, Burma, for the year ended 30th June, 1927.	Ditto.	Ditto.
36	Annual Report of the Pyinmana Agricultural Station, Burma, for the year ended 30th June, 1927.	Ditto.	Ditto.
37	Annual Report of the Allanmyo Agricultural Station, Burma, for the year ended 30th June, 1927.	Ditto.	Ditto.
38	Annual Report of the Tatkon Agricultural Station, Burma, for the year ended 30th June, 1927.	Ditto.	Ditto.
39	Annual Report of the Mandalay Agricultural Station, Burma, for the year ended 30th June, 1927.	Ditto.	Ditto.
40	Annual Report of the Pwinbyu Agricultural Station, Burma, for the year ended 30th June, 1927.	Ditto.	Ditto.
41	Annual Report of the Mudon Agricultural Station, Burma, for the year ended 30th June, 1927.	Ditto.	Ditto
42	Annual Report of the Padu Agricultural Station, Burma, for the year ended 30th June, 1927.	Ditto.	Ditto.

No.	Title	Author	Where published
	General Agriculture—contd.		
43	Annual Report of the Mahlaing Agricultural Station, Burma, for the year ended 30th June, 1927.	Issued by the Department of Agriculture, Burma	Government Printing, Burma, Rangoon.
44	Annual Report of the Akyab and Kyaukpyu Agricultural Station, Burma, for the year ended 30th June, 1927.	Ditto.	Ditto.
45	Annual Report of the Sa-aing (Thayetmyo District) Agricultural Station, Burma, for the year ended 30th June, 1927.	Ditto.	Ditto.
46	Annual Report of the Hmawbi Agricultural Station, Burma, for the year ended 30th June, 1927.	Ditto.	Ditto.
47	Annual Report of the Mycologist, Burma, for the year ended 30th June, 1927.	Ditto.	Ditto
48	Annual Report of the Entomologist, Burma, for the year ended 30th June, 1927.	Ditto.	Ditto.
49	Annual Report of the Agricultural Chemist, Burma, for the year ended 30th June, 1927.	Ditto.	Ditto.
50	Annual Report of the Economic Botanist, Burma, for the year ended 30th June, 1927.	Ditto.	Ditto.
51	Annual Repot of the Agricultural Engineer, Burma, for the year ended 30th June, 1927.	Ditto.	Ditto.
52	Annual Report of the Principal, Agricultural College, Burma, for the year ended 30th June, 1927.	Ditto.	Ditto.
53	Guide to the Punjab Agricultural College and Research Institute, Lyallpur.	Issued by the Department of Agriculture, Punjab, Lahore.	Government Printing, Punjab, Lahore.
54	Report on the Lawrence Gardens, Lahore, for the year 1926-27.	Ditto.	Ditto.
55	Seasonal notes for October, 1927 .	Ditto.	Ditto.
56	Seasonal and Crop Report of the Punjab for the year 1926-27.	Ditto.	Ditto.

No.	Title	Author	Where published
	General Agriculture—contd.		
57	Tables of Agricultural Statistics of the Punjab for the year 1926-27.	Issued by the Department of Agriculture, Punjab, Lahore.	Government Printing, Punjab, Lahore.
58	The Feeding of Adult Poultry. Punjab Department of Agriculture Leaflet No. 47.	Ditto.	Ditto.
59	Poultry Houses and Runs. Punjab Department of Agriculture Leaflet No. 48.	Ditto.	Ditto.
60	How to feed cows in milk. Punjab Department of Agriculture Leaflet No. 49.	Ditto.	Ditto.
61	Poultry keeping for Punjab Farmers. Punjab Department of Agriculture Leaflet No. 52.	Ditto.	Ditto
62	How to begin poultry keeping. Punjab Department of Agriculture Leaflet No. 3.	Ditto.	Ditto.
63	Hints on the sowing of *Toria*. Punjab Department of Agriculture Leaflet No. 54.	Ditto.	Ditto.
64	The *Journal of the Mysore Agricultural and Experimental Union* (Quarterly). Annual Subscription Rs. 3.	Mysore Agricultural Experimental Union.	Bangalore Press, Bangalore.
65	The *Journal of the Madras Agricultural Students' Union* (Monthly). Annual Subscription Rs. 4; Single copy As. 6.	Madras Agricultural Students' Union.	The Electric Printing Works, Coimbatore.
66	The *Planters Chronicle* (Weekly) .	United Planters' Association of South India.	Diocesan Press, P. B. 455, Madras.
67	The *Nagpur Agricultural College Magazine* (Quarterly). Annual Subscription Rs. 3.	R. A. Ramayya and R. B. Ekbote, Editors.	Udyama Desha Sevak Press, Nagpur.
68	*Poona Agricultural College Magazine* (Quarterly). Annual Subscription Rs. 2-8; Single copy. As. 10.	College Magazine Committee, Poona.	Agricultural College, Poona.
69	The *Old Boys' Magazine, Agricultural College, Cawnpore* (Quarterly). Price As. 8 per copy; Annual Subscription Rs. 2.	M. L. Saksena, L. Ag., Editor.	Cawnpore Printing Press.

No.	Title	Author	Where published
	General Agriculture—concld.		
70	The *Allahabad Farmer* (Quarterly). Single copy As. 8 per year Rs. 2.	W. B. Hayes, E. W. Jeremy J. N. Shivpuri.	The Mission Press, Allahabad.
71	The *Bengal Agricultural Journal* (Quarterly) (In English and Bengali). Annual Subscription Re. 1-4. Single copy As. 5.	Issued by the Department of Agriculture, Bengal.	Sreenath Press, Dacca.
72	*Quarterly Journal of the Indian Tea Association.* Price As. 6 per copy.	Scientific Department of the Indian Tea Association, Calcutta.	Catholic Orphan Press, Calcutta.
73	Indian *Scientific Agriculturist* (Monthly). Annual Subscription Rs. 4.	H. C. Sturgess, Editor J. W. Mckay, A.R.C.Sc., N.D.A., Consulting Editor.	Calcutta Chromotype Co., 52-53, Bowbazar Street, Calcutta.
74	*Rural India* (Monthly). Single copy As. 6. Annual Subscription Rs. 3.	A. Swaminatha Ayyar .	President, Forest Panchayet Banking Union, Madras.
	AGRICULTURAL CHEMISTRY.		
75	Experiments on the Feeding of Sorghum silage and concentrate of Scindi calves. Memoirs of the Department of Agriculture in India, Chemical Series, Vol. IX, No. 5. Price As. 9 or 10*d*.	F. J. Warth, M.Sc., Physiological Chemist, Imperial Department of Agriculture and Shri Kant Misra.	Government of India, Central Publication Branch, Calcutta.
76	The Mechanical Analysis of Tropical Soils. Pusa Agricultural Research Institute Bulletin No. 172. Price As. 3 or 4*d*.	J. Charlton, M.Sc., F.I.C., Agricultural Chemist, Burma.	Ditto.
	BOTANY.		
77	The *Kolamba* Rice of the North Konakan and its Improvement by Selection. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. XIV, No. 7. Price Rs. 1-4 or 2*s*.	R. K. Bhide, Crop Botanist to Government of Bombay, Poona and S. G. Bhalerao, B. Ag., Superintendent, Rice Breeding Station, Karjat.	Ditto.
78	*Pennisetum typhoideum*: Studies on the *Bajri* crop: 1 The Morphology of *P. typhoideum*. Memoirs of the Department of Agricultue in India, Botanical Series, Vol. XIV, No. 8. Price As. 12 or 1*s*. 3*d*.	S. V. Godbole, M.Sc., B. Ag.	Ditto.

No.	Title	Author	Where published
	Botany—contd		
79	Studies in Khandesh Cotton, Part I. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. XV, No. 1. Price Re. 1-4 or 2*s*. 3*d*.	S. H. Prayag, M.Ag., Cotton Breeder, Khandesh.	Government of India, Central Publication Branch, Calcutta.
80	Colour Inheritance in Rice. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. XV, No. 4. Price As. 6 or 8*d*.	S. K. Mitra, M.Sc., Ph.D., Economic Botanist to Government of Assam.	Ditto.
81	The Improvement of Indian Wheat. (A brief summary of the investigations carried out at Pusa from 1905 to 1924 including an account of the new Pusa hybrids). Pusa Agricultural Research Institute Bulletin No. 171. Price As. 8 or 10*d*.	Albert Howard, C.I.E., M.A., Director of the Institute of Plant Industry, Indore, and Agricultural Adviser to States in Central India (formerly Imperial Economic Botanist, A.R.I., Pusa.)	Ditto.
	MYCOLOGY.		
82	Fruit-rot disease of cultivated cucurbitaceae caused by *Pythium aphanidermatum* (Eds.) Fitz. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. XV, No. 3. Price, As. 6 or 8*d*.	M. Mitra, M.Sc., F.L.S., First Assistant to the Imperial Mycologist and L. S. Subramaniam, F. L. S. Assistant to the Imperial Mycologist.	Government of India, Central Publication Branch, Calcutta.
83	*Asterina* spp. from India . .	Dr. Duth Ryan, Rosary College, River Forest, Illinois, U.S.A.	Ditto.
	Meliola spp. from India and one from Malay.	Prof. F. L. Stevens, Urbana, Illineis, U.S.A.	Ditto
	Memoirs of the Department of Agriculture in India, Botanical Series, Vol. XV, No. 5. Price, As. 4 or 5*d*.		
84	The loose smut of wheat. Punjab Department of Agriculture Leaflet No. 46.	Issued by the Department of Agriculture, Punjab.	Government Printing, Punjab, Lahore.
	ENTOMOLOGY.		
85	Four New Indian Gall Midges.	E. P. Felt, D.Sc., State Entomologist, New York.	Government of India, Central Publication Branch, Calcutta.
	The Citrus Psylla (*Diaphorina citri*, Kuw) (Psyllidae : Homoptera). Memoirs of the Department of Agriculture in India, Entomological Series, Vol. X, Nos. 1 and 2. Price, Re. 1-2 or 2*s*.	Mohammad Afzal Husain, M.Sc., M.A., Offg. Imperial Entomologist, Pusa, and Dina Nath, L. Ag., B.Sc., Assistant Entomological Section, Department of Agriculture, Punjab.	

No.	Title	Author	Where published
	Entomology—contd.		
86	The use of Hydrocyanic Acid Gas for the Fumigation of American Cotton on Import into India (Experiments on its lethal power for the Mexican Boll-weevil (*Anthonomus grandis*) and for the grain weevil (*Sitophilus oryzae*) on the extent to which it is absorbed by cotton and jute respectively and on a practical method for satisfactory fumigation on a large scale. Price, Rs. 2 or 3*s*. 9*d*.	A. James Turner, M.A., B.Sc., Director, Technological Laboratory, Indian Central Cotton Committee, Bombay, and D. L. Sen, M.Sc. Tech., M.Sc., A.I.C.	Government of India, Central Publication Branch, Calcutta.
87	Catalogue of Indian Insects. Part 13. Cicindelidae. Price, Rs. 2-8 or 4*s*. 6*d*.	Mercia Heynes-Wood, B.A., and Cedric Dover, F.E.S.	Ditto.
88	Catalogue of Indian Insects, Part 15. Cecidomyidae. Price, As. 7 or 9*d*.	R. Senior-White, F.E.S., F.R.S.T.M. & H., Malariologist, Bengal Nagpur Railway.	Ditto.
89	List of Publications on Indian Entomology, 1926. Pusa Agricultural Research Institute, Bulletin No. 168. Price, As. 10 or 1*s*.	Compiled by the Offg. Imperial Entomologist and the Imperial Entomologist.	Ditto.
90	Injurious Field rats of Lower Sind and their extermination. Bombay Department of Agriculture, Bulletin No. 138 of 1927. Price, Rs. 7-6.	P. V. Wagle and Khan Bahadur Gul Mohommed.	Yeravda Prison Press, Yeravda.
91	Grey Weevil of Cotton Seedlings. Punjab Department of Agriculture, Leaflet No. 50.	Issued by the Department of Agriculture, Punjab, Lahore.	Government Printing, Punjab, Lahore.
	BACTERIOLOGY.		
92	A Bacterial Soft Root of Garden Poppy. Memoirs of the Department of Agriculture in India, Bacteriological Series, Vol. II, No. 2. Price, As. 5 or 6*d*.	C. S. Ram Ayyar, B.A., First Assistant to the Imperial Agricultural Bacteriologist, Pusa.	Government of India, Central Publication Branch, Calcutta.
93	Seasonal Variations in the Germ Content of Milk at Pusa. Pusa Agricultural Research Institute, Bulletin No. 170. Price, As. 6 or 8*d*.	J. H. Walton, M.A., M.Sc., Imperial Agricultural Bacteriologist.	Ditto.

No.	Title	Author	Where published
	VETERINARY.		
94	Some Diseases of Cattle in India. (A handbook for Stock owners) Revised 1927.	J. T. Edwards, D.Sc. (Lond.), M.R.C.V.S., Director, Imperial Institute of Veterinary Research, Muktesar.	Government of India, Central Publication Branch, Calcutta.
95	Studies in Bovine Lymphangitis. Memoirs of the Department of Agriculture in India, Veterinary Series, Vol. IV, No. 2. Price, Re. 1-3 or 2*s*.	V. Krishnamurti Ayyar, I.V.S., Professor of Pathology and Bacteriology, Madras Veterinary College.	Ditto.
96	Occurrence of Trichomonad Flagellates in the Blood Stream of Fowls. Pusa Agricultural Research Institute Bulletin No. 173. Price, As. 3 or 4*d*.	Hugh Cooper, M.R.C.V.S., and Amar Nath Gulati, M.Sc., Imperial Institute of Veterinary Research, Muktesar.	Ditto.
97	Improvement and Care of Cattle in Bengal (Revised).	P. J. Kerr, I.V.S., and K. McLean, B.Sc.	Superintendent, Government Printing, Bengal.
98	Ditto (in Bengali) .	Rai Sahib S. C. Paul .	Ditto.
99	List of Horse and Cattle Fairs and Shows in the Punjab and Punjab States for the year 1927-28.	Issued by the Department of Agriculture, Punjab, Lahore.	Government Printing, Punjab, Lahore.
100	Annual Report of the Civil Veterinary Department, Burma, for the year ended 31st March, 1927.	Issued by the Civil Veterinary Department, Burma, Rangoon.	Government Printing, Rangoon.
101	The *Indian Veterinary Journal*. (Quarterly). Annual Subscription, Rs. 4 for members of All-India Veterinary Association and Students, Rs. 8 for others.	P. Srinivasa Rao, G.M.V.C., Editor.	Methodist, Publishing House, Madras.

PLATE XIX.

Mosaic

Co 213

Co 213

Hea y

Co 213

ORIGINAL ARTICLES

A FURTHER NOTE ON THE MOSAIC DISEASE OF SUGARCANE.

BY

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Imperial Mycologist

AND

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THE mottling of mosaic disease on the leaves in the thin canes of Northern India, described in a previous note[1], is fairly well illustrated in Plates XIX to XXI of the present article. It is best seen during the active growing period of the cane, for when the cane has reached its full height, the mottling has become less distinct on the older leaves and is clear only on the young leaves. As the cane reaches maturity the mottling is usually still visible, but it may in some cases almost entirely disappear, though sets from such canes reproduce the disease in the next crop. The illustrations show the mottling in various stages on Co. 213, Co. 205, Co. 303 and Hemja and are clear cases. On narrower leaved canes, however, like Co. 270, Co. 275 and Co. 205, the mottling is not usually so distinct.

When we were in Coimbatore recently the Government Mycologist showed us mosaic symptoms on the stems of Red Mauritius and Java Hebbal. This is the first time they have been noted in India and they consist of loss of colour in long blotches (3 inches by ¼ inch is about the longest), death of the tissue immediately below the blotch, shrinking of the blotched area, shrinking of the diameter of the cane and stunting. Such symptoms, however, have not been seen in thin canes in Northern India.

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[1] McRae, W. Mosaic Disease of Sugarcane in India in 1925. *Agri. Jour. India,* XXI, pp.198-202, 1926.

INCIDENCE OF MOSAIC DISEASE IN LOCALITIES IN INDIA.

In addition to the list of localities and varieties of cane infected by mosaic disease already given in this Journal, the following may be recorded.

Bihar.—

Pusa—Co. 223, Co. 273, Co. 294, Co. 295, Co. 296, Co. 298, Co. 299, Co. 300, Co. 303.

Cuttack—Co. 213.

Sepaya—Co. 213, Co. 241, Co. 243.

United Provinces.—

Gorakhpur—Co. 213.*

Raya—Co. 213.*

Punjab.—

Gurdaspur—Co. 205, Co. 223, Co. 244, Co. 250, Co. 251, Co. 260, Co. 262, Co. 267, Co. 272, Co. 275, Co. 276, Co. 277, Co. 287, Co. 288.

Lyallpur—Co. 205, Co. 210, Co. 213, Co. 223.

Assam.—

Karimganj—B. 147.

Jorhat—Co. 9, Co. 213, J 33 A, A2A, A1, B147, Badila.

Burma[1].—

Sahmaw—B 376, D 74, Java Hebbal, Gillman Red, Striped Mauritius.

Mandalay—J 247 (247-B), P. O. J. 33A, P. O. J. 213, Java Hebbal, Gillman Red, Purple Mauritius.

Pyinmana—Co. 210, Co. 213, J 247 (247-B), P. O. J. 213, Java Hebbal, Gillman Red, Ashy Mauritius, Kyauk-Khaung.

Tatkon—Co. 210, J 247, P. O. J. 33A, Java Hebbal, Gillman Red, Striped Mauritius, Ashy Mauritius, Toungoo Yellow.

Allanmyo—P. O. J. 213.

Madras Presidency.—†

Striped Mauritius, Ashy Mauritius, Q 116, Q 813, B 6450, B 6308, D 131, Bontha.

Coimbatore Cane Breeding Station†—Co. 210, Co. 296, Co. 305, ‡M 52092, M 49201, M 35093, M 50921, M 54244, M 55032, M 57015, M 55582, M 57018, M 57163, Green Sport, Kaludai-boothan.

Thick-Cane Breeding Station—Co. 17, B 254, B 3412, H 109, P. O. J. 100, P. O. J. 920, P. O. J. 2696, P 67, M 54349, Mauritius 33, S. H. 22, Bontha, Vellai, Green Sport, Cheribon Brisbane, Pattapatti, Striped Cheribon, Batjan.

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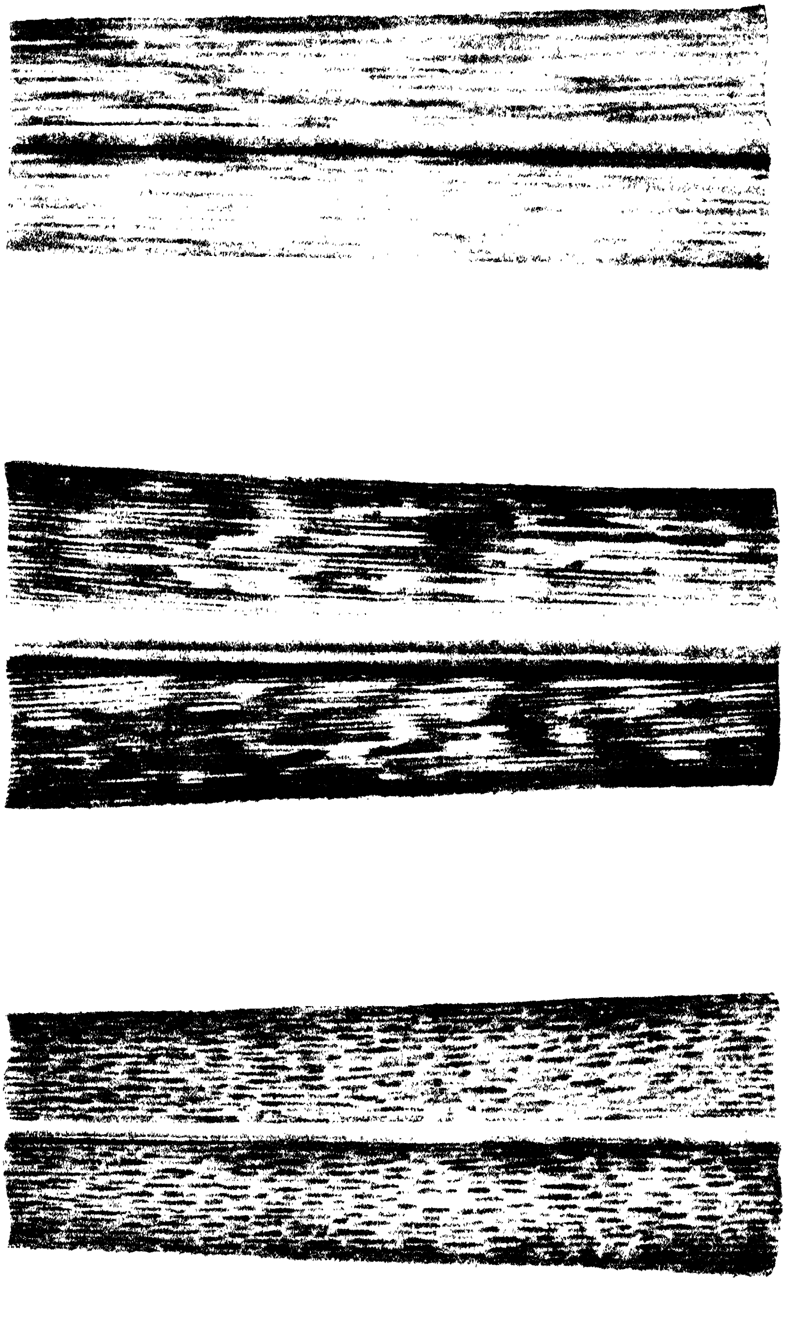
[1] *Annual Report of the Mycologist, Burma, for the year ending June* 1926.

*Reported by the Plant Pathologist, United Provinces.

† Reported by the Government Mycologist, Madras.

‡ These numbers are given in the Cane Breeding Station to seedlings in the preliminary stage of testing.

Mosaic

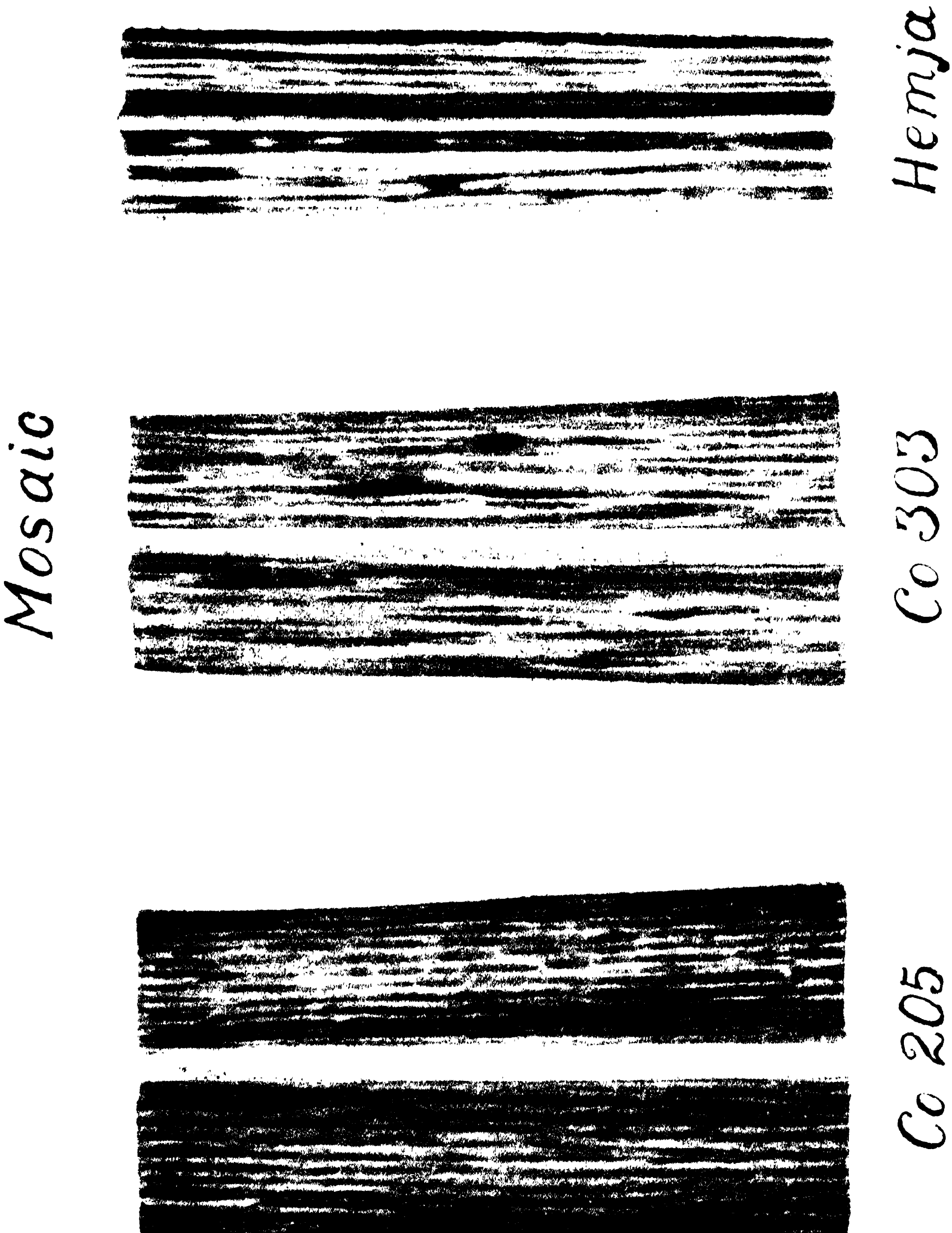


Co 213

Co 213

Co 213

PLATE XXI.



Bombay.—

Manjri—B 208, B 1528, B 6308, H M 165, H M 310A, H M 310B, HM 312, H. M. 315, H 109, J 139, P. O. J. 2727, Cavangerie, Purple Mauritius, Striped local, Black Tana, Java, Waxy Red, Five varieties with Indian locality names.

Amalsad—Co. 213, Striped Mauritius, White Mauritius, Khajuria, Malabari.

Bengal.—

Dacca—Co. 240, D 74.

Fig. 1

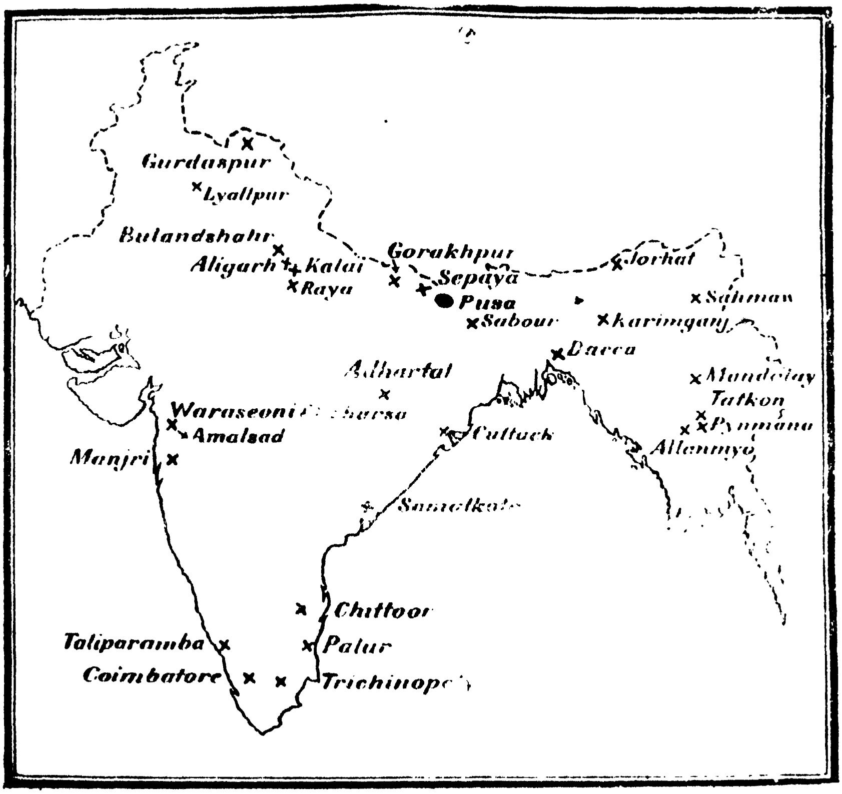


Fig. 1. Localities in India where mosaic disease on sugarcane has been found.

The map in Figure 1 indicates the position of the various agricultural stations in India where mosaic disease has been found. Little, however, is known of the occurrence of the disease outside these agricultural stations. The areas that supply cane to the white sugar factories in the four districts round Pusa have been sampled, a survey of the important cane growing tracts in Madras Presidency has been

made by the Government Mycologist and in Burma the Mycologist has this work in hand.

The following information is taken from the Government Mycologist's report about the survey in Madras:[1]—

"A fairly complete survey was made of the sugarcane tracts of the presidency. In the north over 1,600 acres of cane distributed in the districts of Ganjam, Vizagapatam, and East Godavari came under survey. In Godavari, the taluks of Cocanada, Peddapuram and Ramachandrapur were distinctly invaded by the disease, while Amalapur and Razole showed only a meagre distribution. The varieties affected in these tracts are Red Mauritius, Purple Mauritius, J 247, B 208, D 1135, Striped Mauritius, Ashy Mauritius, Q 116 and Bontha. In the south the districts of South Arcot, North Arcot, Chittoor, Malabar and South Kanara were surveyed. In the eastern districts the disease was present in Cuddalore, Villupuram, Thirukkoyilur, Kallakurichi and Chittoor, while Walajapet, Kalahasti, Voyalpad, Madanapalle and portions of Punganur were free. On the West Coast, South Kanara was free, while certain portions of North and South Malabar showed the disease. The varieties affected in the above areas are Red Mauritius, B 147, M 55, D 625, D 131, J 247, B 208, B 6450, D 1135, Q 813, Q 116, B 6308, Fiji B, Reed and Java-Hebbal. Red Mauritius which is the most widely cultivated variety was by far the most frequently infected. Fiji B* which is reputed to be a resistant variety in other countries has not come up to its reputation in South India, and was in many localities infected. But one pleasing feature of the survey in the south was that the P. O. J. 2714, a robust growing cane and one which has recorded an extraordinary percentage of sucrose, has been singularly free from attack though it was grown in the midst of several susceptible varieties showing heavy infection all round." Mr. Sundararaman has given the following further information :—

"In Godavari district, the infected locality in the north, the percentage of infection varied considerably up to 30 per cent. Probably 10 per cent. is the average. Two varieties, however, in the Samalkot Agricultural Station, Red Mauritius and B 254, had 67 and 35 per cent. infected clumps respectively. In the eastern districts the average infection is about 2 per cent. In some places, however, it goes as high as 50 per cent. In the western districts there is very little infection indeed."

Seeing that the symptoms on thin canes are not easily distinguishable by cultivators, it will be difficult to get them to realize that there is a disease so that any measures found necessary to combat it will have to be done in agricultural stations. But such work is not likely to be undertaken till extensive surveys of cane areas have been made and the magnitude of the problem stated with some degree of accuracy.

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[1] Sundararaman, S. *Administration Report of the Government Mycologist, Coimbatore,* 1926-27.
*Badila or N. G. 15.

AMOUNT OF MOSAIC DISEASE.

(*a*) The amount of mosaic disease on the different varieties of thin canes varies considerably and the variation is well shown in Table I which is a record of the disease on the canes grown *on a field scale* at Pusa. Though, as is usual with most diseases in the field, the diseased plants were scattered irregularly throughout the area occupied by any one variety, still considering the position of the varieties on the farm, it is a reasonable assumption to make that they had an approximately equal chance of becoming infected, hence the figures recorded may be taken as a fairly correct evaluation of the relative susceptibility of the varieties in this environment.

Co. 232 is highly susceptible and has been discarded. Co. 205 is also very susceptible, Co. 250, Co. 287 and Co. 213 are fairly susceptible, Co. 210, Co. 273, Co. 275, Co. 281, Co. 282, Co. 286, and Co. 288 are resistant, while Co. 214, Co. 248, Co. 270, Co. 280 and Co. 290 are highly resistant. The last four canes were grown in the farm only, while about 1,000 acres of the first were grown in the surrounding districts in 1927-28 but no mosaic mottling has ever been seen though this cane has been examined carefully on a large scale.

TABLE I.

Mosaic on sugarcane at Pusa.

	Percentage of mosaic stools				Acres
	1925-26	1926-27	1927-28		1927-28
			June	October	
Co. 205	+	60	4·2	1·2	5·71
Co. 210	2 to 5	0·01	0·01	0	6·44
			0·5		2·60
Co. 213	5 to 10	1·2	0·4	0·02	12·18
Co. 214	0	0	0	0	0·45
Co. 232	90	—	—	—	
Co. 248	0	0	0	0	0·21
Co. 250	20	—	—	—	
Co. 270	0· (2 clumps)	0	0	0	0·60
Co. 273	0·	0·01	0·02	0	2·05
Co. 275	1	0	0·03	0	2·02
Co. 280	0	0	0	0	0·99
Co. 281	3	+	0·2	0·16	0·13
Co. 282	3·6	+	2·6	0·45	0·07
Co. 286	1·7	—	—	—	
Co. 287	15	+	1·1	0·17	0·60
Co. 288	0	+	—	—	
Co. 290	0	0	0·008	0	1·70

The sign — indicates that the variety is no longer grown at Pusa. The sign + indicates the presence of mosaic though the percentage was not determined.

(*b*) The following canes *in the nursery* at Pusa which were free from this disease last year were found to be infected in June 1927.

Co. 294 had 5 mosaic plants or 0·1 per cent.
Co. 295 had 3 mosaic plants or 0·1 per cent.
Co. 296 had 2 mosaic plants or 0·1 per cent.
Co. 298 had 1 mosaic plant or 0·2 per cent.
Co. 299 had 6 mosaic plants or 1·8 per cent.
Co. 300 had 3 mosaic plants or 1·6 per cent.
Co. 303 had 2 mosaic plants or 0·3 per cent.

In addition, Co. 223 had 8 mosaic plants or 5 per cent. It, however, was introduced to Pusa for the first time in 1927.

Co. 297, Co. 301, Co. 302, Co. 304, Co. 306 and BH 10 (12) have shown no symptoms for two years ; thirteen seedling canes from Coimbatore as yet unnumbered, grown in the previous year in the Botanical Area, were free.

Co. 307, Co. 308, P. O. J. 2714, P. O. J. 2725, P. O. J. 2696, P. O. J. 2727 were also free and this is the first season in which they have been grown in Pusa.

Till February 1928 the symptoms have appeared on no other plant in the nursery.

(*c*) With a view to estimate the amount of mosaic disease on the widely grown Coimbatore canes in *North Bihar*, cane-fields on seven estates scattered fairly regularly along a line of 120 miles were examined in July 1927. The record is given in Table II and the percentage indicated is that of mosaic clumps in the area examined.

TABLE II.

Place	Variety	Acres	Percentage
Estate 1	Co. 213	6·0	0·8
	Co. 205	0·5	16·5
Estate 2	Co. 213	5·0	0
Estate 3	Co. 210	5·0	0·05
	Co. 205	3·0	16·0
Estate 4	Co. 213	3·0	0·0*
Estate 5	Co. 213	5·0	0·07
Estate 6	Co. 213	6·0	0·9
Estate 7	Co. 213	4·5	0·2
	Co. 205	1·7	10·0
	Co. 205	1·5	19·0

* Two clumps only were found.

Of 26·5 acres of Co. 213 examined in 6 localities 0·3 per cent. of the clumps were infected, of 6·7 acres of Co. 205 examined in 4 localities 15·4 per cent. and of 5 acres of Co. 210 examined in one locality 0·05 per cent. We believe that these figures indicate correctly the position in North Bihar with regard to those three canes. The percentage of mosaic disease in them is far less than in Hemja which they are gradually replacing.

(*d*) At Manjri Agricultural Station in Bombay Presidency three varieties of cane, Java 33A, Java 36 and Red Mauritius, were found to be infected with mosaic disease in November 1925, whereas twenty-two other varieties of medium and thick canes

that were mostly grown in small plots had become infected by August 1927. Seven of these, *viz.*, B 208, B 1528, B 6308, Cavangerie, Striped local, Java and Waxy Red had scattered cases only, three, *viz.*, H. M. 310A, H. M. 165 and P. O. J. 2727 had up to four per cent., four, *viz.*, H. 109, Purple Mauritius, H. M. 315 and H. M. 310 B had from 30 to 50 per cent., and eight were fully infected, *viz.*, H. M. 312, J. 139, Black Tanna, and the five varieties with Indian locality names. At Amalsad Agricultural Station Striped Mauritius had scattered cases, Malabari one per cent., Co. 213 thirteen per cent., White Mauritius forty-two per cent. and Khajuria 75 to 100 per cent.

(*e*) At Gurdaspur Agricultural Station in the Punjab, thirteen varieties were found to be infected in 1925, whereas in July 1927 fourteen other varieties of thin canes had become infected, of which five had scattered cases, *viz.*, Co. 244, Co. 250, Co. 251, Co. 267 and Co. 276, while the rest had from one to three per cent. It is also interesting to note in certain of the varieties the difference in the amount of infection during the last two seasons in Gurdaspur. In most cases it varies from scattered cases in 1925 to three per cent. in 1927, but Co. 210 had scattered cases in 1925 and ten per cent. in 1927, while Co. 270 and S 48 had scattered cases in 1925 but in 1927 both had 20 per cent. of infected clumps. At Lyallpur Agricultural Station the infection was heavier and reached a maximum of 36 per cent. in Co. 223.

(*f*) In Burma the amount of infection in the different varieties of cane is given in Table III which is copied from the Mycologist's Annual Report for 1925-1926.

TABLE III.

*Mosaic disease in Burma.**

Date	Variety	Per cent. mosaic	Locality	Remarks
1	2	3	4	5
24th January 1926	D 74	90·0	Sahmaw	Plant
Ditto	Ditto	87·7	Ditto	Ratoon
Ditto	B 376	14·4	Ditto	Plant
Ditto	Ditto	6·3	Ditto	Ratoon
Ditto	Gillman Red	3·3	Ditto	Plant
Ditto	Ditto	4·6	Ditto	Ratoon
Ditto	Striped Mauritius	3·0	Ditto	Plant
Ditto	Java Hebbal	3·2	Ditto	Ratoon
20th March 1926	P. O. J. 213	100·0	Mandalay	Plant
Ditto	P. O. J. 33A	100·0	Ditto	Ditto
Ditto	Java Hebbal	100·0	Ditto	Ditto
Ditto	Purple Mauritius	1·0	Ditto	Ditto

* Rhind, D. *Annual Report of the Mycologist, Burma, for the year ending 30th June 1926.*

*Mosaic disease in Burma**—contd.

Date	Variety	Per cent. mosaic	Locality	Remarks
1	2	3	4	5
20th March 1926 . .	Gillman Red . .	50·0	Mandalay	Plant
Ditto . .	J. 247 (247-B) . .	1·0	Ditto	Ditto
18th May 1926 . . .	Gillman Red . .	5·2	Sahmaw	Ratoon
10th June 1926 . . .	Gillman Red . .	1·0	Pyinmana	Plant
Ditto . .	Java Hebbal . .	97·0	Ditto	Ditto
Ditto . .	J. 247 (247-B) . .	0·2	Ditto	Ditto
Ditto . .	P. O. J. 213 . .	99·0	Ditto	Ditto
Ditto . .	Ashy Mauritius . .	10·0	Ditto	Ditto
Ditto . .	P. O. J. 33A. . .	100·0	Ditto	Ditto
Ditto . .	Kyauk-Khaung . .	21·5	Ditto	Ditto
Ditto . .	Co. 210	17·6	Ditto	Ditto
Ditto . .	Co. 213	70·0	Ditto	Ditto
Ditto . .	J. 247	1·6	Tatkon	Ditto
Ditto . .	Striped Mauritius . .	0·2	Ditto	Ditto
Ditto . .	Gillman Red . .	5·7	Ditto	Ditto
Ditto . .	Co. 210	100·0	Ditto	Ditto
Ditto . .	P. O. J. 33A. . .	100·0	Ditto	Ditto
Ditto . .	Toungoo Yellow . .	4·2	Ditto	Ditto
Ditto . .	Ashy Mauritius . .	6·1	Ditto	Ditto
Ditto . .	Java Hebbal . .	100·0	Ditto	Ditto
15th June 1926 . . .	P. O. J. 213 . .	100·0	Allanmyo	Ratoon
Ditto . . .	P. O. J. 213 . .	80·0	Ditto	Plant

*Rhind, D. *Annual Report of the Mycologist, Burma, for the year ending 30th June 1926.*

(*g*) The Dairy Farm at Karnal in the south-east of the Punjab is the only agricultural station we have visited where mosaic disease was not found on cane. Here Co. 205, Co. 213, Co. 223, Co. 287 and Co. 290 are grown on about fourteen acres.

According to the information available, the amount of mosaic disease on the Coimbatore canes is small in North Bihar and comparatively small throughout Northern India where a percentage above 15 is rare. In the tropical parts of India such as Lower Burma, however, the two Coimbatore canes tried, *viz.*, Co. 213 and Co. 210, are fully infected. The thick canes in tropical India and those in Northern India, of which there are few, are much more heavily attacked by mosaic disease, percentages up to 100 being not infrequent. There is general ground then to believe that on the whole the thin canes are resistant. It must not be forgotten, however, that the growing season in Northern India is a short one and probably limits the period of activity of whatever insects carry the disease. This was definitely so in the season 1927-28 during which mosaic symptoms appeared on the leaves from May to September in Pusa, while in Coimbatore they appeared from June to January.

AMOUNT OF SPREAD OF MOSAIC DISEASE BY NATURAL MEANS.

A consideration of the appearance of mosaic symptoms on canes in four plots whose sets were known to have been cut from cane-clumps free from such symptoms for one or more seasons gives an idea of the amount of spread by natural means. Table IV gives the percentage of mosaic clumps for two seasons. In plot No. 1 the non-mosaic sets were taken from canes that are known to have been free from mosaic for four seasons, in plots Nos. 2 and 3 for two seasons and in plot No. 4 for one season. In plot No. 1 non-mosaic canes of Co. 210, Co. 213, Co. 214, Co. 275, Co. 290 and Uba were grown in alternate rows with mosaic sets of Co. 213, Co. 232, Co. 250, Co. 281 and Co. 287. In the first season each line had 50 to 60 clumps, while in the second 80 to 111. The plot was irrigated periodically partly to keep down white ants which are always abundant in newly opened grass land in this locality and partly to ensure against possible shortness of moisture in the soil so that as few as possible of the plants might be lost. In the first season mosaic mottling appeared on the leaves of six per cent. of the plants of Co. 210 during March and April, while in the second season there was no spread on to this variety but there was to both Co. 213 and Co. 275. Eight clumps of Co. 213 showed the leaf-mottling in June and two more near the end of July, while two clumps of Co. 275 showed the signs on the 8th of June.

In plot No. 2 the lines were 160 feet long. Twenty lines of non-mosaic Co. 213 and seven lines of non-mosaic Co. 287 were planted in a block and the same number of lines of mosaic sets were planted in an adjacent block. In plot 3 the lines were 193 feet long and here too were two adjacent blocks of six lines each of mosaic and non-mosaic Co. 213. In both plots the non-mosaic cane was free from mosaic disease during the previous two seasons. These two plots were not irrigated but were grown under estate conditions.

In the first season 0·5 per cent. of the clumps of Co. 213 showed leaf mottlings during *April* and *June*, while in the second 2·1 per cent. showed them during *the months of June* to *September*. Co. 287 had 1·6 per cent. spread.

In plot No. 4 the lines were 93 feet long and the number of sets in each line varied considerably according to the varying length of the internodes. Non-mosaic cane of Co. 205, Co. 281, Co. 250, Co. 273, Co. 213, Co. 275, Co. 280, Co. 286 and Co. 290 alternated with lines of mosaic cane of Co. 232. This plot was in the Kitchen Garden but was not irrigated. The mosaic symptoms appeared on the leaves of four varieties only during the months of April to June. The record of this plot has not quite the same value as the other three, because the non-mosaic sets were taken from canes that appeared to be free from mosaic at the time of planting. The canes had not individually been kept under observation during the growing season though the field as a whole had. We know that some thin canes do lose the markings and though we chose canes with deep green leaves we have no other test that they were free as we do have in the other three experiments.

From the known history of the non-mosaic cane in plots 1, 2 and 3 there can be no doubt about the appearance of mosaic mottling on the leaves being due to infection in the current season by natural means and the figures give a measure of the spread at Pusa in 1927 in the near vicinity of infected canes. In plots Nos 1 and 4 where the non-mosaic plants were side by side with the mosaic, the spread was greater than in plots Nos. 2 and 3 where the two blocks were adjacent.

For cane grown in the field where infected clumps are scattered here and there we have no accurate record of the spread of the disease, but the record of the percentage of mosaic disease in October 1927 in Table I, though it does not directly show the spread of disease, does indicate percentages, that may be equal to or less than but are not greater than those that would represent the true spread. If we assume that all mosaic plants were removed in June (though this is hardly likely) then the percentages would indicate the spread during the season. They vary from 0 to 1·2 per cent. Thus in Pusa, which is sufficiently typical of North Bihar, the spread of mosaic disease in the field in 1927 was probably less than 1 per cent. on those varieties of cane in which the maximum spread took place. In this year the monsoon was light and not evenly distributed, only 39 inches of rain fell instead of an average for 21 years of 46 inches.

TABLE IV.

Percentage of mosaic disease caused by natural spread.

Plot	Variety	Area	Percentage of mosaic clumps	
			1926-27	1927-28
1	Co. 210	1 line of 50-60 clumps in 1926-27 and of 80 to 111 clumps in 1927-28.	6	0
	Co. 213		—	9
	Co. 214	Ditto	0	0
	Co. 275	Ditto	0	2·2
	Co. 290	Ditto	0	0
	Uba	Ditto	0	0
2	Co. 287	14 cents	1·6	1·6 Ratoon
	Co. 213	22 „	0·5	1·2 „
3	Co. 213	7 „	—	2·1
4	Co. 205	1 line of 82 clumps	3·6	
	Co. 281	1 line of 107 clumps	4·7	
	Co. 250	1 line of 90 clumps	1·1	
	Co. 273	1 line of 77 clumps	1·3	
	Co. 213	1 line of 85 clumps 1 line of 84 clumps	0	
	Co. 275	1 line of 88 clumps	0	
	Co. 280	1 line of 104 clumps	0	
	Co. 286	1 line of 94 clumps	0	
	Co. 290	1 line of 95 clumps	0	

This amount of natural spread of mosaic disease in 1927 in Pusa is different from that in a similar experiment in Coimbatore. The Government Mycologist showed us two plots in which a row of each of 24 varieties of non-mosaic thick canes was grown interstripped with alternate rows of mosaic Red Mauritius in the one plot and of mosaic Java Hebbal in the other. Thirty sets had been planted in each row. Taking the average of corresponding rows in the two plots, it was seen that in P. O. J.2727, Fiji C, Q813, Tana, B147, B3412 under 50 per cent. of clumps had become infected, in B6308, B 208, Fiji B, J247, Chittoor Poovan, Java Hebbal, Butjan, Vellai and Purple Mauritius from 50 to 80 per cent., and in B6450, Poovan, D625, D131, D 1135, M55, Q116 and Red Mauritius 80 to 100 per cent. Thus the amount of spread on thick canes in Madras is far greater than that on thin canes in Bihar when the canes are situated in the best position for the spread of the infection, as they were in the experiments immediately under review.

On page 244 is a record of mosaic on certain varieties grown in the Nursery at Pusa. All of the infected canes except Co. 223, which was a new introduction, were free from mosaic in the previous year. The sets of Co. 223 were got from Lyallpur at the planting season. Subsequent examination in Lyallpur showed that the standing crop, whose sets had the same origin as those sent to Pusa, had 36 per cent. of infected clumps in July. It is thus likely that mosaic was introduced into the nursery by this cane and then spread to other varieties. Perhaps a point might be made here for growing canes from other stations in a separate quarantine plot for a season before introducing them into the ordinary cane blocks, otherwise disease is likely to be spread from station to station throughout India as mosaic has been.

Occurrence of mosaic disease on maize.

During August 1927 nine maize plants within 30 yards of Plots Nos. 2 and 3 developed mosaic mottling on their leaves. Three hundred acres of maize on the farm were carefully examined but no other case was found. Fields round Pusa for a mile or two and along three roads to a distance of 15 miles were examined but no mosaic disease was found on maize, *Andropogon Sorghum*, *Eleusine coracana*, *Panicum frumentaceum*, *Setaria italica*, *Cynodon dactylon* and other grasses.

It seems clear that these nine maize plants were infected from the infected cane in the adjacent experimental plot and that mosaic is not on the common cereals of the *kharif* (autumn) crop in the vicinity of Pusa. Both maize and Sorghum have been infected artificially from sugarcane and the former naturally, so there is a possibility that mosaic disease will pass from cane to these two crops. This it has done already in some other countries, such as the United States, Porto Rico, Hawaii, Trinidad, Queensland and South Africa, and in some of them recommendations

not to grow these crops in rotation with sugarcane have been made. Maize is a common crop in some cane-growing areas of Northern India and Sorghum in tropical India. If mosaic disease is going to pass to these two crops and they become infected to any great extent, not only will there be an additional problem to solve but that on sugarcane will become more complicated. Seeing that maize and Sorghum are now known to be susceptible to mosaic disease in India it seems just as likely that they will become infected as sugarcane has been, so that the danger is a real one and this problem of mosaic disease is well worth intensive study by all the departments of agriculture in India. Too much dependence should not be placed on work at Pusa where the disease is light, the spread is slow and facilities are none too abundant. What we have seen in Coimbatore on a recent visit shows that what happens in North Bihar is hardly comparable with that in South India. Information about incidence in sugarcane and other plants and the spread of the disease is required in each main cane-growing tract. That work has been begun in the Punjab, Bombay, the United Provinces and Madras, we know, and we hope that it will become at once a main subject of investigation.

Germination.

The number of shoots that germinate and come above ground is small compared with the number of buds in the sets planted, as seen in Table V. In healthy Co. 213 it is 44 per cent. on irrigated land and 32 on unirrigated land. The Government Sugarcane Expert found from observations in the varietal plots in the Cane-breeding Station at Coimbatore that in 44 Coimbatore seedlings the percentage of germination in the central buds was 64 and in the end buds 42. This would correspond to a germination of 49 per cent. in the field where three-bud sets were planted. As the fields in the Cane-breeding Station are irrigated, the conditions correspond to those in the irrigated plot at Pusa, and the percentages of germination in the two places, *viz.*, 49 and 44, are comparatively near. That the germination in the unirrigated field, *viz.*, 32 per cent., is somewhat lower is to be expected as the moisture content of the soil is much less. The germination in sets from mosaic cane is lower by 13 per cent. in the irrigated and by 8 per cent. in the unirrigated land. The germination of mosaic infected Co. 287, Co. 232, and Co. 205 is also low, remarkably so in the last variety. As there is no cane of these three varieties so definitely known to be free from mosaic as that of Co. 213 under experiment, the relative difference in germination between mosaic and non-mosaic cane of these three varieties cannot be found with accurracy this year. These data especially with regard to Co. 213 indicate that there is a possible loss through lower germination in mosaic cane.

TABLE V.

Germination of sets from mosaic and non-mosaic cane.

Plot			Length of line	No. of sets planted	No. of eyes	No. of shoots	Percentage of shoots to sets	Ratio of shoots to sets	Percentage of shoots to eyes
No. 1	Non	Co. 213	78′	84	252	111	132	100	44
	Mosaic	Co. 213	78′	81	243	73	90	68	30
	Mosaic	Co. 213	78′	76	228	71	93	70	31
	Mosaic	Co. 213	78′	86	258	81	94	71	31
	Mosaic	Co. 287	78′	93	279	83	90	..	30
	Mosaic	Co. 232	78′	87	261	65	75	..	22
	Mosaic	Co. 205	78′	75	225	56	75	..	15
No. 3	Non	Co. 213	1158′	1475	4425	1432	97	100	32
	Mosaic	Co. 213	1158′	1570	4710	1139	72	74	24

INFECTION EXPERIMENTS.

In the infection experiments given in Table VI juice was crushed from mottled leaves and immediately pricked into leaf-sheaths and stems of plants known to be free from mosaic disease. An adequate number of plants were used as controls and into them juice from known non-mosaic plants was pricked, but in no case did mosaic mottling appear on the leaves. The disease has been passed from Co. 213 into four other varieties and into maize, from Co. 205 into three other varieties and into maize and Sorghum, from Co. 210, Co. 232, Co. 287 and Red Mauritius into maize and from Co. 232 to Sorghum. It has also been passed from maize infected from Co. 210 to other maize. The experiments demonstrate that the disease can pass from one variety of cane to another, from one variety of cane to Sorghum, from several varieties of cane to maize and from maize so infected to other maize. We tried to infect cane from maize and Sorghum without success, but the failure is more likely to be due to inadequate technique than to the possible inability of the virus to infect cane and attention will be paid to this point next year.

TABLE VI.

Infection Experiments.

——	No. of shoots inoculated	No. of shoots showing mosaic	Date	Incubation period in days
Co. 213 to Co. 213	13	8	24-6-26	30
	16	8	19-4-26	37
	11	2	16-6-27	26
Co. 213 to Co. 205	6	2	16-6-27	27
Co. 213 to Co. 232	4	1	16-6-27	37
Co. 213 to Co. 275	8	3	16-6-27	33
Co. 213 to Red Mauritius	1	1	16-6-27	26
Red Mauritius to Co. 213	16	16	10-4-26	45
Co. 205 to Co. 213	30	2	18-6-27	25
Co. 205 to Co. 275	10	1	22-6-27	33
Co. 205 to Co. 210	10	9	22-6-27	33
Co. 205 to Uba	4	1	22-6-27	33
Co. 210 to Co. 210	10	4	24-6-27	25
Co. 213 to Maize	17	5	29-7-26	10
	10	3	25-8-26	10
Red Mauritius to Maize	16	4	31-7-26	10
Co. 205 to Maize	4	2	18-6-27	9
	60	1	20-7-27	26
Co. 232 to Maize	61	9	20-7-27	14
Co. 287 to Maize	60	6	22-7-27	12
Co. 210 to Maize	56	10	23-7-27	11
to Maize	61	42	10-8-27	11
Maize to Maize	6	2	19-8-27	6
Co. 232 to Jowar	4	1	18-6-27	21
Co. 205 to Jowar	4	2	18-6-27	10

Roguing.

The time of appearance of mosaic mottlings on the leaves of cane from mosaic and non-mosaic plants is given in Table VII. We had to make up our minds as to the exact point of time when we would enter a plant as showing the symptoms, and we decided to wait till the markings were so clear as to be easily recognizable by an ordinary person looking for them. We did so because we wished to get information that would help with regard to the efficacy of roguing. These two plots were planted from the 10th of February, 1927, onwards. At the end of April the number of shoots of Co. 213 that originated from mosaic sets and on the leaves of which mosaic mottling was clearly recognizable was 82 per cent. in the irrigated land, 75 per cent. in the unirrigated land, while on the 10th of June the percentage was 98 and 90 respectively. Mosaic in Co. 287 and Co. 232 showed up more quickly and by the 10th of June in every plant its presence was visible. In Co. 205, however, symptoms appeared much more slowly. These facts have a bearing on roguing. To be a practical method of dealing with the disease, roguing should be done as few times as possible in order to keep down expense, and yet it should be efficacious in reducing the disease substantially. A controlling factor is the spread of the disease. On the 24th June 8 plants or 7 per cent. in the non-mosaic line of Co. 213 in No. 1 plot had mosaic mottling on their leaves and on 26th June five plants or 0·3 per cent. in the non-mosaic Co. 213 in plot No. 3 also had it. In plot No. 1 every alternate line is mosaic material, so the non-mosaic plants are in a good position to become infected. The non-mosaic plants are from cane that has been observed to be free from mosaic for four seasons. In the plot No. 3 the non-mosaic cane is grown alongside the mosaic cane. The former was taken from plants that showed no signs of mottling on their leaves for two seasons. Hence these mosaic plants in the non-mosaic lines had been infected this season some time after planting. None of the mosaic plants were removed so that every chance was given in the experiment for the spead of the disease. The carrier was not observed and the exact time of infection is not known. However, in the experiments of 1926 and 1927 the interval between "pricking in" the virus and the appearance of mosaic mottling on the leaf varied from 29 to 45 days. Thus it is possible that the infection of the plants in these plots took place as early as the 10th of May. Roguing should accordingly be done before this date, say on the 1st May. Then 75 per cent. of the mosaic plants of Co. 213 in estate condition will have become visible and removeable before spread begins. By the 10th of June, just before the monsoon is expected to arrive, another 15 per cent. will be visible *plus* 0·3 per cent. of spread. These facts show the efficacy of roguing. As much of the cane in North Bihar is grown in large blocks even up to 40 acres, it is not feasible at present to rogue all this and if the spread is so slow every year as it has been during the last two seasons it does not seem necessary. But it is well worth while to rogue a sufficiently large area to provide ample seed for the next season. The cost in labour will be comparatively small but the workers will have to be carefully trained to re-

cognize the disease. On the Pusa Farm the cane crop was rogued in 1926 and in 1927 at the time of planting and in every case where the same variety of cane has been grown during those seasons the percentage of mosaic has been substantially reduced. In October 1927 an examination of the cane showed that the percentage still present after roguing was small and indicates that roguing has to be continued for several seasons. Though in Co. 210 and Co. 275 no mosaic canes were found, we shall have to wait till the next actively growing season in June before being sure that this is a fact and not an oversight of a very small quantity. The Cane Breeding Station at Coimbatore also affords a good example of the possibility of preventing mosaic disease from getting hold of a small cane area. In 1923 and 1924 a few sets were exported to Mauritius and Cuba respectively and developed mosaic there, so it is presumed that there was a small amount of mosaic disease in the station then. In 1925 the junior writer found no mosaic. In February 1926 the senior writer found two clumps after examining every one in the area. Later in the year 19 clumps and a single short row were found and all were completely dug up and destroyed immediately they were seen. In 1927-28 though the station was examined at various times by both the writers and by the Government Mycologist and his staff only one case of mosaic disease was found. The disease was carried to the station from infected fields near by but a careful outlook and prompt roguing has prevented its spreading.

Similarly the results of two years' selection work at Shahjahanpur[1] Sugarcane Research Station in the United Provinces have been successful. Some canes such as the Poundah varieties are very susceptible and often show as much as 100 per cent. infection. In the first year the percentage was brought down to 5 and in the second to 0·1. Measures of control have been carried out at all demonstration centres in the Circle where improved varieties of cane are being grown with equally successful results and the Deputy Director thinks that there is every prospect of mosaic being controlled in the more important of the new varieties of improved cane such as Java and the selected Coimbatore seedlings.

As mentioned already[2], roguing is the only method of reduction applicable in the field that has been found of any value in other countries, and it has been now shown to be of value in India. The substitution of a highly resistant variety for all the locally grown susceptible varieties as has been done with Uba in Porto Rico and Natal is being left out of consideration as not being practicable in India at present.

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[1] *Report of the Agriculture Stations of the Rohilkhand Circle, Shahjahanpur*, 1927.

[2] *Scientific Reports of the A. R. I., Pusa* (*Rept. of the I. M.*,) 1926-27, p. 51 ; *Agri. Jour. of India*, Vol. XXII, p. 14, 1927.

TABLE VII.

Number and percentage of recognizable mosaic clumps.

		No. of clumps	30-4-27 No.	30-4-27 %	17-5-27 No.	17-5-27 %	23-5-27 No.	23-5-27 %	10-6-27 No.	10-6-27 %	24-6-27 No.	24-6-27 %	10-7-27 No.	10-7-27 %	27-7-27 No.	27-7-27 %	12-8-27 No.	12-8-27 %	27-8-27 No.	27-8-27 %	12-9-27 No.	12-9-27 %
Plot 1.																						
Non . .	Co. 213	111	0	—	0	—	0	—	0	—	8	7	..	..	10	9						
Mosaic . .	Co. 213	73	57	78	67		68	97	68	97	70	100										
Mosaic . .	Co. 213	71	61	86	68	97	70	100														
Mosaic . .	Co. 213	81	67	83	74	95	75	96	75	96	77	99										
Mosaic . .	Co. 287	83	82	99	83	100																
Mosaic . .	Co. 232	65	61	94	64	98	64	98	65	100												
Mosaic . .	Co. 205	56	28	50	32	57	37	66	50	90	52	93	55	98	56	100						
Plot 3.																						
Non . .	Co. 213	1432	0	—	0	—	0	—	0	—	5	·3	—	—	18	1·5	21	1·7	24	2	31	2·1
Mosaic . .	Co. 213	*1139	873	75	943	85	958	89	966	90	973	91	976	91	994	93	997	94	1005	95	1012	9·6

* A small number of plants were destroyed by white ants and these have been taken into consideration when calculating the percentages.

TEA IN NORTH-EAST INDIA, III.

BY

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(Continued from Vol. XXIII, Pt. 3.)

TEA SOILS OF NORTH-EAST INDIA.

MOST of the tea soils of North-East India are what is classed by geologists as new alluvium. As the Assam Valley was formed with the upheaval of the Himalayas to the north and the raising of the Barail range to the south, between what is now Assam and Burma, the Brahmaputra and its tributaries laid down soils which have from time to time been washed away or covered with newer deposits.

Near the Himalayas, in the Dooars and at the foothills along the north bank of the Brahmaputra, tea is often put out on the gentle slopes rising to the hills. These slopes, formed from the detritus washed down from the mountains, form banks of well drained loams of a bright red colour and referred to as Red Bank. In the Dooars and the Terai are also new alluvial soils washed from the areas in the immediate vicinity. The soils laid down by the Brahmaputra are generally high in insoluble silicious matter, but the alluvial soils of the Dooars contain less quartz and more minerals decomposed by acid.

In the Surma Valley the soils vary according as they are taken on *teelas*, flats or *bheels*. The *teelas* are hillocks of red sandstone, closely related to the sandstones of the Naga Hills in the Brahmaputra Valley. The valleys or flats between these hillocks may be sands or clays according to the slope of the land, for these areas are generally formed by washings from the *teelas* or by deposits laid down by rivers which have backed up during flood periods of the river Surma. The *bheels* are peaty bogs usually surrounded by *teelas*.

The general slope of the Brahmaputra Valley is greater than 6 inches per mile with the result that most of the silt is carried away by the river and only the coarser particles deposited. In cases where loams occur, as on the Doom Dooma bank, the soil has been deposited by smaller rivers which may have had their slope changed from time to time with the successive rises and falls of the valley.

The gradient of the valley is shown by the following heights of towns, given in feet above sea level.

Sadiya	440 ft.	Tezpur	256 ft.
Dibrugarh	340 ft.	Gauhati	163 ft.
Sibsagar	319 ft.	Goalpara	150 ft.

The distance from Sadiya to Goalpara is about 400 miles.

The south bank of the Brahmaputra, backed as it is by the sandstones of the Naga Hills, yields soils devoid of stones except near the Mikir Hills and Shillong plateau. Stones are abundant in the Dooars and on the north bank as far as Brahmakund, above Sadiya, where the Himalayas end, and the crystalline rock gives place to sandstone.

The first table shows typical soils from the Brahmaputra Valley.

Brahmaputra Valley.

Typical soils.

	Dibrugarh	Jorhat	Bishnath
	per cent.	per cent.	per cent.
Mechanical analysis.			
Coarse sand	16	5	56
Fine sand	34	55	24
Silt	12	18	11
Fine silt	15	11	2
Clay	17	6	3
Loss on ignition	5·9	2·9	3·2
Chemical analysis.			
Organic matter (Grandeau)	1·8	1·4	1·3
Nitrogen	0·10	0·08	0·08
Total phosphoric acid	0·087	0·04	0·057
Available phosphoric acid	0·015	0·008	0·011
,, potash	0·015	0·008	0·005
,, lime	0·16	0·016	0·038
Acidity (Hopkins)	650	500	300
Insoluble silicious matter	79	93	90

The Dibrugarh soil is typical of the Lakhimpur District which comprises about 100,000 acres of tea and the finest area in North-East India. The soils here have been laid down by the Dehing and Noa Dehing river systems and thus came from the Naga Hills. On this account they show a lower percentage of insoluble silicious matter than do the soils laid down by the Brahmaputra. Besides being well supplied in plant food they are deep soils.

The Jorhat soil is taken from near Tocklai and represents the average soil of the district. The insoluble silicious matter is high and the soil generally poor. The crop in such areas is naturally far below that of Dibrugarh.

The Bishnath district is on the north bank where the soil is often light and poor. This district suffers from drought on account of the lightness of the soils, although once the tea is established it does well.

The second table contains an example of a Darjeeling soil formed *in situ*, a Red Bank soil, a Mal sand and a grey sandy loam, all from the Dooars. These last three types also occur on the Terai.

Darjeeling and Dooars.

Typical soils.

	Darjeeling	Mal sand	Red Bank	Grey sandy loam
	per cent.	per cent.	per cent.	per cent.
Mechanical analysis.				
Coarse sand	23	64	19	5
Fine sand	10	16	10	31
Silt	13	4	12	29
Fine silt	27	7	18	25
Clay	20	4	33	6
Loss on ignition	6·80	4·8	7·8	3·5
Chemical analysis.				
Organic matter (Grandeau)	5·22	2·4	2·8	1·4
Nitrogen	0·18	0·12	0·12	0·09
Total phosphoric acid	0·09	0·081	0·15	0·16
Available phosphoric acid	0·019	0·019	0·014	0·06
„ potash	0·04	0·009	0·018	0·017
„ lime	0·05	0·02	0·028	0·145
Acidity (Hopkins)	840	150	800	120
Insoluble silicious matter	71	85	68	82

The Darjeeling soil is typical of many formed *in situ* in this district, although some resemble the Red Bank soil shown in another column. The accumulation

of fine silt appears to indicate a distinction for this class of soil. In the valleys of Darjeeling, many of the soils are alluvial resembling the Mal sand and grey sandy loam of the Dooars.

The Mal sands occur in the Terai and the western Dooars and are probably old alluvial deposits which have remained water-logged and thus collected plant food, in which they are now remarkably rich. The insoluble silicious matter is lower than might be expected, suggesting that much of the sand of these soils is soluble in acid and is not quartz as is the case generally in Assam. The Mal sands are black, but in the south Terai are examples of these soils raised on banks and well aerated. The result is a red Mal sand much poorer than the average black type.

The Red Bank soil may be taken as typical of most of these soils formed by weathering. The characteristic is coarse and fine particles as major fractions, a state of affairs not possible with water borne soils. The Red Bank soils are among the richest tea soils of North-East India. The Red Bank generally abuts the Hills, although in one or two cases isolated outcrops occur.

The grey sandy loams are the newest soils in the Dooars and as such are rich in lime and phosphoric acid. In some cases patches of alkaline soils occur, and here the tea is poor or fails to grow at all. It is usually found that, within limits, the best tea soils are the most acid ones.

The third table shows soils from the Surma Valley.

Typical Surma Valley soils.

	Teela	Flat	*Bheel*
Mechanical analysis.	per cent.	per cent.	per cent.
Coarse sand	32	*nil*	*nil*
Fine sand	36	17	7
Silt	6	16	7
Fine silt	9	27	26
Clay	11	28	11
Loss on ignition	5·6	8·1	33·9
Chemical analysis.			
Organic matter (Grandeau)	2·4	3·7	20·4
Nitrogen	0·15	0·20	0·57
Total phosphoric acid	0·34	0·068	0·194
Available phosphoric acid	0·16	·005	0·053
,, potash	0·13	0·014	0·036
,, lime	0·06	0·083	0·024
Acidity (Hopkins)	500	1200	2500
Insoluble silicious matter	92	75	55

The *teela* soil is typical of the red hillocks which are a distinctive feature of Cachar and Sylhet. These *teelas* carry good tea, although some of the southern slopes suffer badly from drought and too much sun.

The flat is a common type of heavy clay, difficult to handle unless generously green-cropped. The *bheel* is also typical. These peat soils produce enormous crops, up to 2,000 lb. of tea per acre. After twenty years or so they deteriorate, often owing to over drainage, as a result of which they lose their colloidal properties through repeated drying, and become "fluffy."

Practically all the tea soils of North-East India are acid. In a few cases in the Daina-Toorsa district of the Dooars small patches of recently deposited soil are neutral or just alkaline, and either fail to grow tea, or do so indifferently. The higher limit of soil acidity tolerated by tea has not yet been fixed, but soils with an acidity as high as 3,000 parts lime per million (Hopkins), and a p^H value as low as 3·8, grow good tea. Soils showing practically no acidity by the Hopkins method but a p^H value of about 6·5 may be successful as tea soils, but a neutral soil with $p^H = 7$ is not good for tea.

PLANTING.

The most sought after land for tea planting is well drained jungle land, although great areas of grass land are also growing fine tea. Low-lying land, usually referred to as rice land, does not do well unless it is sufficiently high lying to be drained. Many of the best areas in Assam were formerly occupied by bamboo forest and the *teelas* of the Surma Valley carry bamboo.

Tea seed is grown in seed gardens which are usually attached to tea gardens. North-East India, with its dry, cold weather, is particularly suited to the formation and ripening of tea seed, and in most districts are good seed gardens from which are annually despatched many maunds of seed to the tea growing districts of the world.

Some of the best known seed gardens are planted out as follows. The bushes are planted 10 × 10 feet square and centre pruned when about 4 years old. After about 10 years, alternate diagonal rows of bushes are cut out leaving the planting 14 × 14 feet triangular. The stems of the bushes are kept clean and sprayed with lime-sulphur solution to a height of about 5 feet.

The method of collecting and sorting tea seed is as follows. The seed pods and seeds are collected after they have fallen and placed in damp, shallow sand pits, covered with dried grass, for a few days, after which time the pods are easily removed. After shelling, the seed is placed in a water-tank and, of the sinkers, a certain number are split and examined. If these are 90 per cent. or more good (*i.e.*, not more than 10 per cent. "starred") they are dried and sold. If they show less than 90 per cent. sound they are put back in the pits for four or five days and then refloated and a fresh test made of the sinkers. A "starred" seed is one which has been attacked by the tea seed bug (*Poecilocoris latus*) and shows a white patch when it is cracked and opened.

The light seeds or floaters are also tested and if they contain less than 50 per cent. good seed, they are burnt. If there are 50-60 per cent. good, they are put back in the

pits for four or five days and then again put in the water-tank. The sinkers are tested as before.

The sinkers which have passed the test are dried weekly in the sun and the split seed removed. Split seed, however, is capable of growing good plants.

It will be understood that on putting out a seed garden it is necessary to pick the seed bushes with care. Broadly speaking, there are four varieties of tea bush seen in tea gardens in North-East Ind a, the China, the Assam or light-leaved indigenous, the Burma or dark-leaved and the Manipuri bush. In the plains districts of North-East India the large-leaved varieties are preferred. The dark-leaved bush is hardier than the light-leaved Assam bush, and although both yield about the same, the Assam bush is thought to give the better tea. In Darjeeling, where the climate is severe, the China type of bush is preferred. In the Dooars and the Surma Valley, where climatic conditions are often difficult, the dark-leaved variety is favoured, but in the Brahmaputra Valley the light-leaved bush of the Assam, Burma or Manipuri varieties is preferred generally.

Light-leaved seed bushes yield about 5 maunds of seed per acre and dark-leaved, about double that quantity.

Tea is planted out from seed which it is preferable to germinate before planting in the nursery. This does not ensure better plants but a more even nursery. The seed is generally available in November or December and the nurseries are put out as early as possible.

The nursery bed is usually made in the jungle, conveniently near the area to be planted. The soil is thoroughly cleaned but not hoed too deeply, otherwise the lifting of clods when the seedling is transplanted is a difficulty. The seeds are planted at distances varying from 4 inches to 8 inches square according to the age at which the plants will be lifted. Experiment had shown that the following distances are advisable :--

For 6 months	plants,	plant	5	in.	apart.
,, 12	,,	,,	,,	8	,,	,,
,, 24	,,	,,	,,	10	,,	,,

The seed-bed which is usually about 5 feet wide is well drained and shaded, either by grass laid on as a mulch or by overhead grass shading, supported by a bamboo framework. Experiments have shown that shade about 5 feet high yields the best results. In a season which starts with a bad drought a nursery may be a total failure unless it is shaded, and even in good years, shading increases the number of successful seedlings by as much as 50 per cent. Shade is sometimes provided by sowing dhaincha (*Sesbania aculeata*) near the beds during the first spring.

The seeds are planted about half an inch deep with the eye downwards. This latter is an important point, because a straight good tap root, without any twist, is necessary to a good tea plant. If the tap root is not sound or if it is damaged or cut in transplanting, it is likely that the bush when it matures will be a poor leaf yielder.

Tea seedlings are generally replanted at about 8 to 14 months, and only selected plants are removed from the nursery. The plant is lifted intact in a clod of earth. If the clod is broken during lifting or in transit, the plant is discarded, otherwise it is carefully carried to the clearance where a hole has been dug for its reception.

Sometimes seed is planted at stake in a clearance. It is usual in such cases to plant three or four seeds at each stake and to uproot all but the best when the seedlings have grown big enough for selection. In the case of a bad drought, seed at stake suffers badly since it is usually impracticable to water a large area.

In many cases "carrot" planting, by which method the plant is lifted without the clod, has been tried, but this method does not yield such good plants as does the clod method. In Ceylon and South India "stump" planting is a general method. With stump planting the seedling is cut a few inches above the ground and then uprooted and replanted. Most planting in North-East India is done in the dry season and on this account the clod method gives such better results.

When planting out new areas, 8-12 months old plants are best, but for infilling vacancies in planted tea or for re-planting old tea lands, older plants are often used.

The usual distance apart for planting tea bushes is 4 ft. 6 inches triangular which gives 2,483 bushes per acre. There are on an average about 16,000 tea seeds in a maund (80 lb.) and about 3 or 4 acres of tea are planted out from this number of seeds. The loss is accounted for by bad seed and weakly seedlings.

Pruning.

Growing wild the tea plant is a tall shrub and it is converted into a bush of convenient pluckable height by pruning.

The young tea plant is made into a bush by one of two methods. The first is to let it grow for 2 or 3 years and then to cut it between one and four inches above the ground. By this method a secondary or coppice growth is induced and the bush takes on a spread. This method was once popular in Assam but has lately been to some extent changed. Another method is to cut the young plant straight across at about 18 inches and to remove one or more of the central branches. By this means the bush is made to spread without cutting a thick piece of wood.

At the Experimental Station at Tocklai many methods of forming a young tea bush have been tried, and the conclusion arrived at, is that centring is preferable to collar pruning, as low cutting is termed, for giving a big crop during the early years. After collar pruning the next cut is sometimes made as high as about eighteen inches or just below one foot. The lower cut gives a wider bush than the higher one.

Most of the tea—at least 90 per cent. on established gardens—consists of formed bushes which are top pruned each year or every other year. The object of top pruning is to cut the bush back leaving about one inch of last year's wood and at the same time removing weakly twigs. Thus each year the woody portion of the bush gets higher, until finally it is too high to pluck. When this is the case the bush is heavy pruned.

Heavy pruning is undoubtedly the most difficult problem in pruning. In Upper Assam it is common to cut the bush right down to the ground at intervals of 20 years or less, and to build up a new frame again. In other districts it is the custom to cut the bush through where the spread is fairly broad, back to thick wood. In this case the bush sends out new shoots from an inch or often much more below the cut and a dead piece of wood remains. These dead snags form entry places for fungus diseases which may kill the entire branch and eventually the bush. The more healthy the bush the less are snags liable to form, and on this account it is advisable to manure tea well and to pluck it lightly the season before it is cut back.

In Ceylon, South India and Java, where the bush flushes all the year round, it is usual to prune every other year or at some of the higher elevations every three, four or even five years. Such a custom also holds in Darjeeling, not because the bushes flush continuously but because the growth is slow.

In many districts in North-East India it is customary to leave a large percentage of the tea unpruned each year. Thus when the bush stops flushing in November or December it is left till the next March or April, when the spring flush appears, and is then again plucked. The advantage from this system is that the crop is gathered early when labour is available. A grave drawback to unpruned tea is the risk of severe early drought, in which case the bush carrying full foliage suffers badly. Another disadvantage is that unpruned tea invariably suffers from fungus attack and from red spider much more than does pruned tea.

At the end of the plucking season it often happens that the top of the bush is irregular because it has not been possible to pluck the leaf as fast as it grows. In this case "skiffing" or "switching" is sometimes practised. This consists in cutting the bush across level, just below the last season's plucking marks. By this means the foliage is reduced and a flat plucking surface is formed, ready for the coming season.

Tea cannot be left unpruned indefinitely for with each season the leaf becomes smaller and more difficult to gather and eventually too much flower is produced at the expense of leaf. In addition, leaving bushes unpruned is a strain on the plant and one year of such treatment is generally considered enough. Apart from the problem of labour for plucking and pruning, the gain from biennially pruned tea over annually pruned tea is small over a period of years, even in the absence of severe droughts.

The best time for collar pruning tea in North-East India is September, when the food stores of the plant are at a maximum. This is seldom carried out in practice, however, because it entails the loss of half the season's crop on the collar pruned area. In pruning, the effect of the drought must always be kept in mind, for the conservation of soil moisture is a problem of prime importance. A bush in full foliage takes much moisture from the soil and it sometimes happens that if the pruning is done at the end of February or in March, the soil has become so dry that when the spring flush appears, as it does whether the rains have started or

not, there is insufficient soil moisture for it to carry on. The result is a bad start to the season. Top pruning is done in December and January, followed by deep cultivation with which the prunings are buried.

PLUCKING.

After a bush is pruned, buds burst from the wood and a new shoot begins to grow. The first leaf that unfolds is not a normal, serrated leaf, such as usually grows on the bush, but a small, smooth edged leaf known as the *janum* (Hind.—birth). The next leaf may also be misformed, but usually is of normal growth and size.

If the shoot is left to grow and the bush is vigorous, it elongates throughout the season, growing fastest in the spring and autumn. If the bush is a weakly one or if the branch is weak, as many side branches are, after the growth of four or five leaves comes a resting period, during which the bud ceases to grow or becomes *banjhi* (Hind.—sterile), but the leaf beneath it develops normally. After a variable period, perhaps as long as twelve weeks, the *banjhi* shoot again begins to grow with the formation first of a *janum* leaf, and then of a series of normal leaves.

It is common to pluck two leaves and a bud for tea making, although often three or four leaves are taken if the object is to make a large crop rather than a fine tea. In North-East India it is usual to fix on a plucking height and to take all shoots of two leaves and a bud which appear above this height. This height, measured from the ground, is seldom below 27 inches and is often much higher. On tea which has been medium pruned at least 9 inches of new growth is allowed before plucking. On a top pruned bush 6 inches is left. Six inches equals about three leaves growth in the centre of a vigorous bush.

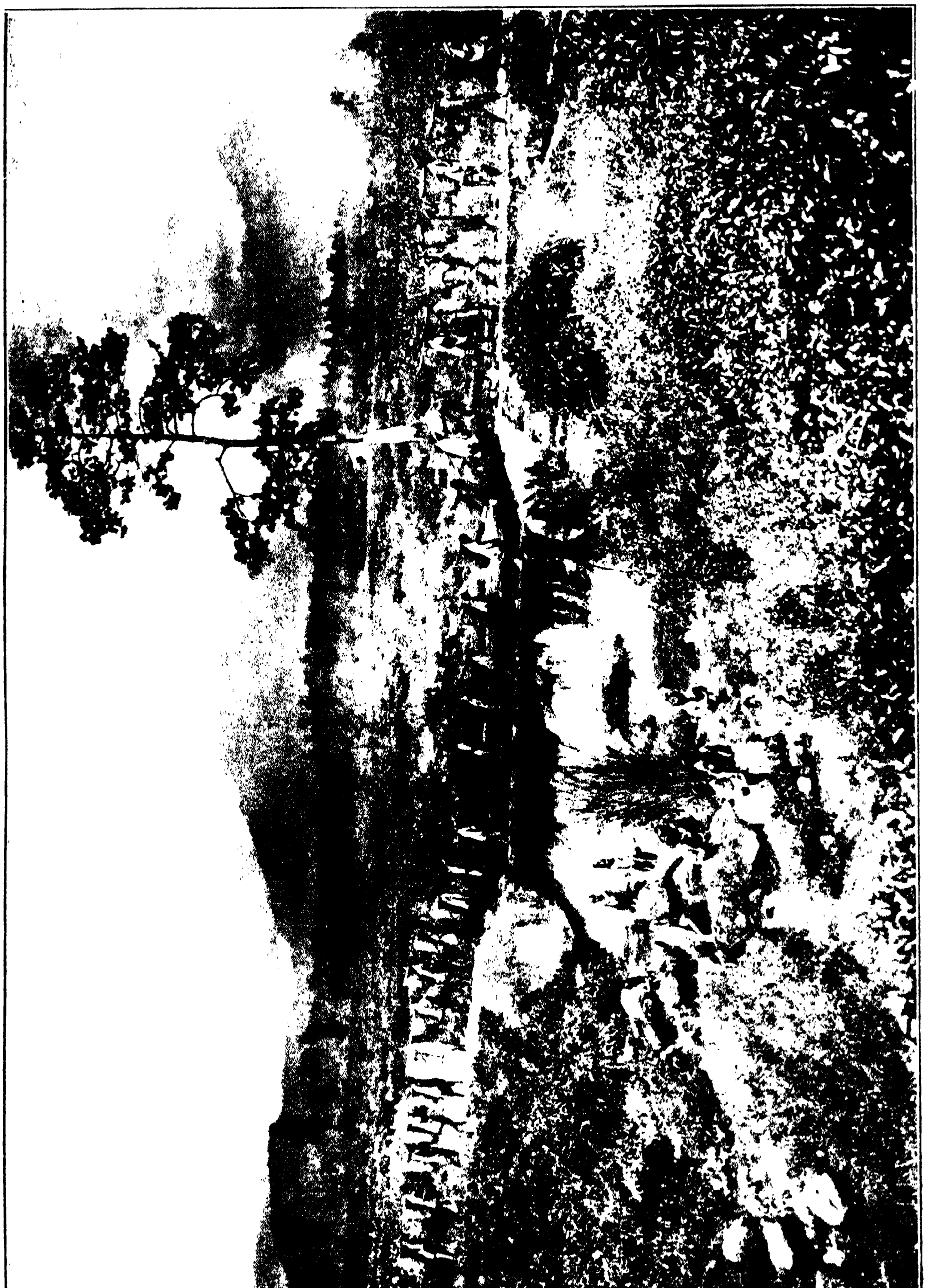
The correct plucking of a bush is the most important operation on a garden, since too severe plucking may ruin the health of the bush and too light plucking may result in a serious loss of crop. When the height of the tipping, as the first plucking is called, is fixed, there are still several ways of plucking subsequently. The most severe method is to continue to pluck all shoots of two leaves and a bud which appear above the plucking table. A more lenient method is to let the new shoots grow to three leaves and a bud and then to pluck two and a bud, leaving one fully developed leaf. In some areas, notably the Dooars and Surma Valley, it is common to let the shoot grow to four leaves and a bud and to pluck above two big leaves after the first tipping. When the shoots have reached the second level, the next shoots are either plucked as soon as they develop to two leaves and a bud above that level, or three leaves and a bud are allowed to develop and two and a bud are plucked. The bush thus gets higher as the season advances.

As already stated, in some gardens where the tea is vigorous, the bush is plucked down at the original plucking level, but generally some growth is given on the second flush and after that a level, plucking surface is aimed at. Often, owing to labour shortage, the shoots grow long before they can be plucked and then only the top of

TEA SHOOTS, NATURAL SIZE.

It is usual to pluck two and sometimes three leaves and a bud.

PLATE XXIII.



General view of a tea garden in the Dooars.

the shoot can be taken. At the end of the season the tops of the bushes on many gardens thus present an irregular appearance.

Nowadays the advantage of not plucking the sides of the bushes till they grow level with the plucking table is realized. By this treatment a greater plucking surface is obtained, for the sides eventually strengthen up till they are almost as strong as the centre. A still greater advantage accruing from this treatment is that the soil is covered with foliage and weed growth retarded.

In North-East India the bushes begin to flush with the spring impulse in April or May, and the first tipping is made at a definite height. The second flush comes in about June, and the teas then made are well supplied with "tip" and bring high prices. The gardens of Upper Assam produce much "tip" because the pruning in this area is severe and the early shoots produce fat buds which, on rolling, display the ultimate bud leaves. These small leaves remain a golden colour after manufacture and constitute the "tip." Unpruned tea or tea which has not been cleaned out in the pruning gives little "tip."

There are, broadly speaking, six flushes in the season although the bushes are plucked every week if labour is available. After the second flush, which is a very definite one, the others are not well marked because shoots growing from axils below the plucking table in time reach the plucking level and give a continuous supply of leaf.

The autumn teas usually possess flavour which brings big prices. The flavour is believed to be due to the slower rate of growth at this period. During the hot rainy season, a shoot takes about three weeks to develop from an axil after the shoot above has been plucked. In the autumn, the growth may take as much as six weeks according to climatic conditions.

Plucking may be coarse or fine, close or long. Fine plucking consists in two leaves and a bud and coarse plucking in three or four leaves. Fine plucking makes for quality. The composition of a shoot by weight is shown below.

Bud	14 per cent. of shoot plucked.
First leaf	21 ,, ,, ,,
Second leaf	38 ,, ,, ,,
Stalk	27 ,, ,, ,,
	100 ,,

The tannin content of the various leaves and stalk are shown below.

	Tannin per cent.
Bud	27·9
First leaf	27·9
Second leaf	21·3
Third leaf	17·8
Fourth leaf	14·5
Upper stalk (Bud to second leaf)	11·7
Lower stalk (2nd to 4th leaf)	6·4

Long plucking means plucking at a distance from the old wood of a bush. Tea which has been heavy pruned must be plucked on a long growth of new wood, otherwise the bush suffers. As the bush gets older and the top wood thickens up, the plucking may be made close, to within about six inches, of this wood. Close plucking makes better tea than long plucking, and the best tea is made by plucking close and fine.

(To be continued.)

INDIA AND THE LEAF TOBACCO TRADE OF THE BRITISH EMPIRE.

BY

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THE principal feature of the British tobacco trade in recent years has been the increase in the consumption of the cigarette type of tobacco and the relative decrease in the consumption of the types used for pipe tobaccos and cigars. The imports of tobacco into the United Kingdom are larger now than before the war and American bright flue-cured tobacco, which in England is popularly called "Virginian," constitutes the bulk of the tobacco used in the British industry. In recent years the tobacco trade of the United Kingdom has shown a steady increase in the use of tobacco grown within the British Empire and the increasing share which Empire grown leaf now takes in the tobacco trade of the United Kingdom may be gauged from the following figures, which show the percentage shares of the Empire and foreign countries in the total imports of leaf tobacco into the United Kingdom during the last 6 years and before the war.

Percentage shares of Empire grown leaf and foreign grown leaf in the imports of unmanufactured leaf tobacco into the United Kingdom.

	1909-13 average annual per cent.	1922 Per cent.	1923 Per cent.	1924 Per cent.	1925 Per cent.	1926 Per cent.	1927 Per cent.
Empire grown leaf . .	1·3	6·8	8·0	10·6	10·0	15·1	18·4
American grown leaf . .	88·5	90·2	89·0	86·0	86·1	81·9	79·9
Other foreign grown leaf .	10·2	3·0	3·0	3·4	3·9	3·0	1·7
	100	100	100	100	100	100	100

The total consumption of leaf tobacco in the United Kingdom has increased from 185 million pounds in 1922 to 222 million pounds in 1927 ; the fall of 10 per cent. which has resulted in the share of American leaf in the total imports into the United Kingdom corresponds to an actual rise in the total quantity of imports from America, imports from America being 167 million pounds in 1922 and 177 million pounds in 1927. On the other hand, the fall of about 8 per cent. in the share of other foreign grown leaf in the total imports into United Kingdom corresponds

to an actual fall in the imports from these sources from 13 million pounds in the pre-war period to about 4 million pounds in 1927. The increased use of Empire grown leaf has not therefore affected imports from America as seriously as it has those from other foreign countries.

The actual amounts of Empire grown leaf tobacco imported into the United Kingdom during these years are as follows :—

	lb.
Yearly average of 1909-13	1,698,000
Imports in 1922	12,654,000
,, ,, 1923	12,895,000
,, ,, 1924	19,297,000
,, ,, 1925	18,921,000
,, ,, 1926	29,795,000
,, ,, 1927	40,941,000

The increase in the consumption of Empire grown leaf has been steady and received a great stimulus in 1919 when a tariff preference of one-sixth of the ordinary rate of duty was granted to Empire grown tobacco. This was increased in 1925 to one-fourth, and in 1926 this preference was stabilised for a term of ten years. The present full rate of duty on unmanufactured stripped tobacco imported into the United Kingdom is eight shillings and ten pence half penny (8-10½) per lb. if it contains 10 per cent. or more moisture and nine shillings and ten pence (9-10) per lb. if it contains less than 10 per cent. moisture. The preferential rates are six shillings nine and seven-eighths pence (6-9⅞) on tobacco containing 10 per cent. or more moisture and seven shillings six pence three farthings (7-6¾) on tobacco containing less than 10 per cent. moisture. The saving of over two shillings per pound in the duty on Empire grown leaf, in comparison with that on foreign grown leaf, has led to lower retail prices in certain classes of cigarettes on the market in the United Kingdom and the public are slowly acquiring a taste for Empire grown tobacco. At the present moment no part of the Empire has succeeded in producing a tobacco which can be substituted entirely for the American leaf in the manufacture of high grade cigarettes; the Empire grown leaf can, however, be used in conjunction with the American leaf in the manufacture of lower grade cigarettes and is being so used on an increasing scale in Great Britain.

Many territories of the Empire are sharing in the import of tobacco leaf to the United Kingdom. Some of the finest Empire grown leaf is grown in Nyasaland, where European settlers have effected great improvements in the production of bright leaf of high quality. This is reflected in the exports from Nyasaland to Great Britain which have risen from a yearly average of 1,502,000 lb. in the period 1909-13 to 4,800,000 lb. in 1921 and to nearly 14,000,000 lb. in 1927. In Rhodesia, as in Nyasaland, there has been a steady improvement in the quality of the tobaccos produced by the settlers and the exports have risen from 53,000 lb. in the pre-war period to 2,300,000 lb. in 1926. In both countries, however, the bulk of the tobacco

crop still consists of poor quality dark leaf produced by native cultivators. Canada has shown a marked response to the preferential tariff granted to Empire tobaccos in the British market and the production of tobacco in Canada has increased from a yearly average of about 9,000,000 lb. before the war to the record of nearly 44,000,000 lb. in 1927. Canada has a considerable advantage over some other parts of the Empire inasmuch as she has a splendid market for her tobacco production at home as well as by export to the United Kingdom; the increasing importance of this export trade is shown by the fact that exports from Canada to the United Kingdom have risen from a yearly average of 2,000 lb. in the pre-war period to 4,900,000 lb. in 1926.

India's share in the imports of Empire grown leaf into the United Kingdom is an important one and, in fact, until 1927 India supplied a larger amount of leaf tobacco to the United Kingdom than any other part of the Empire. Of the total imports of Empire grown leaf into the United Kingdom, the percentage quantity coming from India has in recent years been as follows:—

1909-13 yearly average	1922	1923	1924	1925	1926	1927
Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1·24	31·0	35·0	43·6	41·2	39·8	20·6

Of the total exports of unmanufactured leaf tobacco from British India, the United Kingdom takes a very much larger quantity than any other country. Aden, Straits Settlements, Federated Malay States and Hongkong are the next largest customers within the Empire, and among foreign countries Germany, the Netherlands and Japan are the biggest consumers. Exports of unmanufactured tobacco from India which amounted to 27 million pounds in 1923 reached the record figure of 47 million pounds in 1924 but declined to 33 million pounds in 1925 and to 28 million pounds in 1927. Of these exports the annual proportion consumed by the United Kingdom was as follows:—

1922	1923	1924	1925	1926	1927
Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
18	13	19	23	33	30

During these years the proportion of India's total exports of leaf tobacco consumed by countries within the British Empire varied from approximately 50 to 75 per cent.

The feature of these figures is the preponderance of Empire territories in the consumption of this valuable export and the steady rise in the proportion of the total export consumed by the United Kingdom. It is worth noting, however, that in the last year (1927) India provided only 20 per cent. of the total amount of Empire grown tobacco consumed in the United Kingdom instead of 40 per cent. as in preceding years. Up to the present Indian leaf has been used in the United Kingdom principally for mixing with other leaf in the preparation of pipe tobaccos and for this purpose a bright yellow leaf is not so essential as in the preparation of cigarette tobaccos. It is significant that those Empire sources of supply from which more tobacco was imported into the United Kingdom in 1927 than in 1926, particularly Nyasaland, are making every endeavour by scientific cultivation, seed selection and up-to-date curing equipment to produce a type of cigarette tobacco which will compete favourably with that imported from America. The future of the tobacco trade appears to lie more and more with the production of the cigarette type of tobacco and the decline in the imports of Indian grown leaf into the United Kingdom, relative to leaf grown in other parts of the Empire, which is shown in 1927, suggests that an organized scientific effort to produce bright tobacco in India will have to be made if India is to maintain her position in the market of Great Britain.

Annual imports of unmanufactured leaf tobacco into the United Kingdom from Empire and foreign sources.*

	1909-13 yearly average	1922	1923	1924	1925	1926	1927
Empire—							
British India	21	3,935	4,575	8,412	7,785	11,854	8,448
Canada	2	855	956	1,787	1,859	4,914	†
South Africa	28	59	51	197	24	488	†
Rhodesia	53	360	367	726	1,031	2,305	†
Nyasaland	1,502	6,735	5,891	6,882	7,070	9,084	13,887
British North Borneo	7	593	894	840	830	895	†
Other British possessions	85	117	161	453	322	255	18,606
TOTAL	1,698	12,654	12,895	19,297	18,921	29,795	40,941
Foreign—							
United States	116,288	166,822	154,859	156,938	162,719	161,410	177,512
Other foreign countries	13,430	5,381	5,284	6,187	7,341	5,998	3,870
TOTAL	129,718	172,203	160,143	163,125	170,060	167,408	181,382
GRAND TOTAL	131,416	184,857	173,038	182,423	188,981	197,204	222,323

* Year ends 31st December. Imports stated in thousand lb.
† Separate figures not available.

LONGEVITY OF CROP SEEDS.

BY

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In the course of our seed testing work, we have often found seed samples, apparently quite sound, to be defective in germination. Age was usually suggested as the reason, but we had no precise data regarding this point. There is a common belief that crop seeds more than a year old do not germinate satisfactorily and that an addition of another year renders them completely unfit for use. With a view to ascertain the facts, a longevity experiment was conducted in the seed-testing laboratory of the Poona College of Agriculture. The experiment is now in its sixth year and judging from the results obtained so far, it would appear that it will still be several years before the seeds entirely lose their viability. Seeds from crops grown on the College Farm were used for the tests. Each sample after drying and cleaning was divided into sixteen sub-samples stored separately in glass bottles with a naphthaline ball in each bottle. The bottles were then sealed. Each bottle contained about 4 oz. of seed. One bottleful was a year's sample and was tested once every three months, the bottle being resealed after each test.

The germination tests were carried out indoor in the laboratory by simple methods. Excepting *bajri* (*Pennisetum typhoideum*) and *til* (*Sesamum indicum*), all the seeds were tested in flower-pots which were filled up with dry leaves or cuttings of *kadbi* with a thick layer of fine sand on the surface. Water was supplied by capillary action from below. *Bajri* and *til*, being tiny seeds, were tested in small porous petri dishes which were placed in a seed germinating incubator.

Average germination percentage each year (average of the four annual tests).

Common name	Botanical name	Germination percentage				
		1922	1923	1924	1925	1926
Bajri	*Pennisetum typhoideum*	94·5	93·6	89·1	87·0	61·2
Jowar	*Andropogon Sorghum*	89·7	90·7	90·8	84·5	79·1
Wheat	*Triticum sativum*	97·6	98·2	97·3	99·1	98·1
Maize	*Zea Mays*	96·0	97·3	96·2	89·6	86·7

Average germination percentage each year (average of the four annual tests) —contd.

Common name	Botanical name	Gemination percentage				
		1922	1923	1924	1925	1926
Tur . . .	*Cajanus indicus* . .	93·5	89·2	91·1	88·1	87·1
Mug . . .	*Phaseolus mungo* . .	77·2	93·6	97·1	94·5	96·7
Matki . . .	*Phaseolus aconitifolius* .	90·2	93·8	93·7	91·6	93·3
Udid . . .	*Phaseolus mungo* var. *radiatus*.	72·2	98·1	97·3	97·7	98·3
Gram . . .	*Cicer arietinum* . .	96·6	99·8	98·0	93·2	97·5
Hulga Kulti . .	*Dolichos biflorus* . .	99·0	98·5	98·2	98·1	97·6
Kabuli gram . .	*Cicer arietinum* . .	97·0	99·0	98·7	96·7	97·2
Cotton seed . .	*Gossypium neglectum* .	58·6	67·3	58·0	55·8	53·3
Groundnut (Small Japan).	*Arachis hypogea* . .	92·6	74·5	60·2	28·5	23·8
Safflower . . .	*Carthamus tinctorius* .	97·3	98·5	96·6	96·6	94·7
Til	*Sesamum indicum* . .	85·6	85·8	85·6	79·2	80·5
Linseed . . .	*Linum usitatissimum* .	98·0	97·3	93·7	94·1	93·0

It will be seen from the foregoing table that excepting groundnut and *bajri* all the crops that have been tested have maintained a high percentage of germination throughout five years without appreciable decrease. Groundnut, however, rapidly lost its viability, especially after the third year. A comparative graph of the behaviour of *jowar* and groundnut is given in Chart I. *Bajri* seed retained its high germination for four years but fell off in the fifth. The pulses are specially noticeable for their continued high viability. The pulses *mug* and *udid* gave a germination percentage of 50·5 and 21 respectively when tested in January 1922 immediately after harvesting, the remaining seeds being impermeable "hard"

seeds which gradually became permeable in the course of nine months to a year and then gave almost 100 per cent. germination.

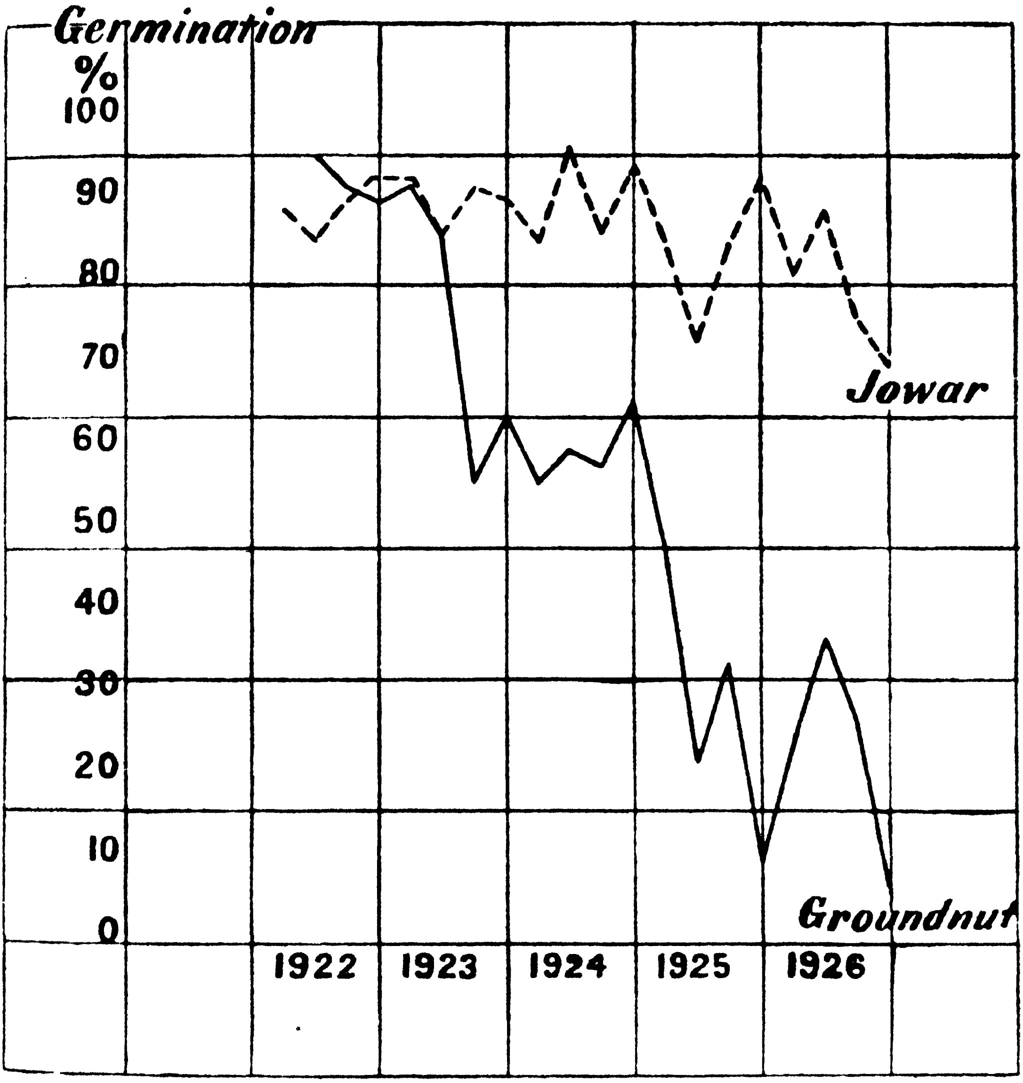


CHART I.

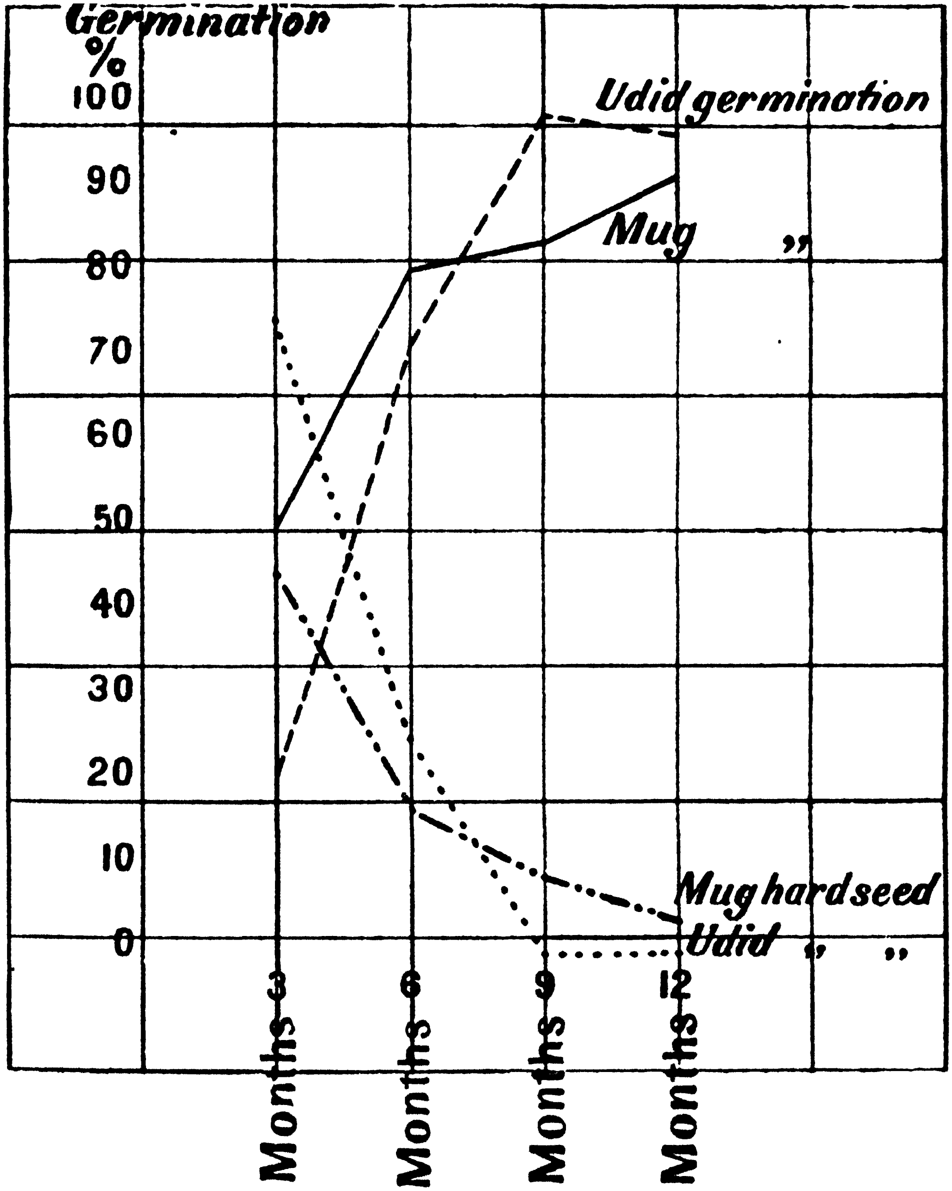
The following table and Chart II illustrate the gradual increase in germination and fall in the hard seed percentage (seed which subsequently became permeable).

Gradual decrease in "hard" seed percentage.

1922

Mug			Udid		
Month of testing	Germination	Hard seed	Month of testing	Germination	Hard seed
		per cent.			per cent.
January . . .	50·5	45	January . .	21	75·5
March . . .	81·5	17	March . . .	72	25
June . . .	84·5	9	June . . .	99	0
October . . .	92·5	4·5	October . .	97	0

CHART II.



The presence of hard seeds and their behaviour in storage has already been discussed by Prof. G. B. Patwardhan, Assistant Professor of Botany, College of

Agriculture.[1] It was shown that *mug* and *udid* which just after harvest show the presence of a large number of hard seeds or seeds impermeable when tested for germination after about a year germinate readily. The usual procedure in seed testing is to consider half the number of such hard seeds as germinable on the assumption that those seeds may germinate at some future unknown date when sown in the field. As a matter of fact in this respect nothing reliable was known till the present work was done. The presence of such hard seeds was found to be so enormous that Mr. G. D. Mehta, once in charge of this seed testing section, recommended scarifying such seed so as to obtain uniform germination.[2] The present work shows that scarification is not necessary. Given time, the hard seeds will germinate.

The seeds when stored for this experiment appeared to be free from living weevils, yet one *matki* sample which was sealed by over-sight without a naphthaline ball was so damaged by weevils that within a year the contents became a heap of unrecognizable rubbish, while all the other *matki* samples in which the naphthaline balls had been placed were free from weevils. This clearly proves that the naphthaline effectively prevents hatching or growth of weevils in seed. The only objection to the use of naphthaline is that it renders the seed useless for human food. This objection, however, does not affect seed stored for sowing.

The figures given justify the following statements :—

(1) With the exception of groundnut and to a less extent *bajri*, the crop seeds tested have lost little germinating power over five years.

(2) The so-called "hard" seeds of the pulses tested lose their hardness within a year of harvesting and storage.

The experiments are being continued.

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[1] *Poona Agri. College Mag.*, Vol. XIX, No. 1, July 1927, p. 5 (Hard coated seeds and their vitality).
[2] *Bombay Agri. Dept. Bull.* 37 (1910), pp. 15 and 17.

A PRELIMINARY NOTE ON THE EFFECT OF MANURIAL CONSTITUENTS ON THE QUALITY OF SUGARCANE JUICE AND *GUR*.

BY

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THE major portion of the cane grown in India is utilized for the production of *gur* (unrefined raw sugar), and consequently any factors which affect the quality of the juice also affect the quality of *gur* produced from it. Whilst these differences may be inappreciable in the high quality thick canes, the same does not hold in regard to the thin canes of inferior quality grown in North India. Here a reduction in quality may readily lead to the production of a very inferior *gur*.

During the last five years a number of analyses have been made under varying manurial treatments which seem to indicate that the quality of the cane juice was affected very appreciably by the manurial constituents applied, and with a view to test this observation a series of duplicate plots were laid down at Pusa in February 1926. The cane selected for experiment was Co. 213 and all the plots received identical treatments except in the manures applied.

The scheme of manuring was as follows :—

Plots	Manure applied	Rate
1 and 6	Superphosphate	P_2O_5—100 lb. per acre
2 and 7	Sulphate of potash	K_2O— 50 " " "
3 and 8	Sulphate of ammonia	N —120 " " "
4 and 9	Cyanamide	N —114 " " "
5 and 10	Mustard cake	N —120 " " " K_2O— 20 " " " P_2O_5— 53 " " "

The manures were applied in two doses ; one-third being given on March 3rd, after the germination of the sets, and the remainder on June 21st. Occasional irrigations were given according to crop requirements until the break of the monsoon.

EFFECT OF MANURE ON THE QUALITY OF JUICE.

Periodic analyses of the sugarcane were made from November and continued until 1st February, 1927. The average results of the analyses of sugarcanes from plots are given in the following table and are also plotted as graphs in Charts I, II and III.

TABLE I.

Effect of manure on sugarcane juice.

Plots	% Sucrose (Average of two plots)					% Glucose (Average of two plots)					Coefficient of purity (Average of two plots)				
	Superphosphate 1 and 6	Sulphate of potash 2 and 7	Sulphate of ammonia 3 and 8	Cyanamide of lime 4 and 9	Mustard cake 5 and 10	Superphosphate 1 and 6	Sulphate of potash 2 and 7	Sulphate of ammonia 3 and 8	Cyanamide of lime 4 and 9	Mustard cake 5 and 10	Superphosphate 1 and 6	Sulphate of potash 2 and 7	Sulphate of ammonia 3 and 8	Cyanamide of lime 4 and 9	Mustard cake 5 and 10
1-3 Nov., 26 . .	12·89	10·77	8·54	8·76	9·27	2·06	2·07	2·68	2·59	2·48	73·76	77·27	67·89	79·34	69·76
16-17 Nov., 26 .	13·10	12·11	10·78	10·96	10·90	1·75	1·54	2·06	2·08	1·99	80·88	79·90	76·45	78·70	76·89
1-2 Dec., 26 . .	14·12	13·38	11·92	12·94	13·03	1·17	1·27	1·99	1·86	1·69	83·55	82·34	77·57	80·96	80·50
17-18 Dec., 26 . .	15·51	14·90	13·71	13·38	13·62	0·69	0·77	1·33	1·23	1·32	39·82	88·49	84·27	84·54	84·95
3-4 Jan., 27 . .	16·97	16·41	15·47	15·35	16·77	0·45	0·50	1·03	0·91	0·72	90·19	88·84	85·41	86·61	87·88
19-20 Jan., 27 . .	17·48	17·34	16·53	16·57	17·14	0·29	0·25	0·59	0·55	0·47	91·50	91·43	89·71	90·35	90·56
1-23 Feb., 27 . .	17·01	16·66	15·18	15·45	16·23	0·39	0·56	0·88	0·85	0·67	88·68	87·31	84·47	85·04	86·15

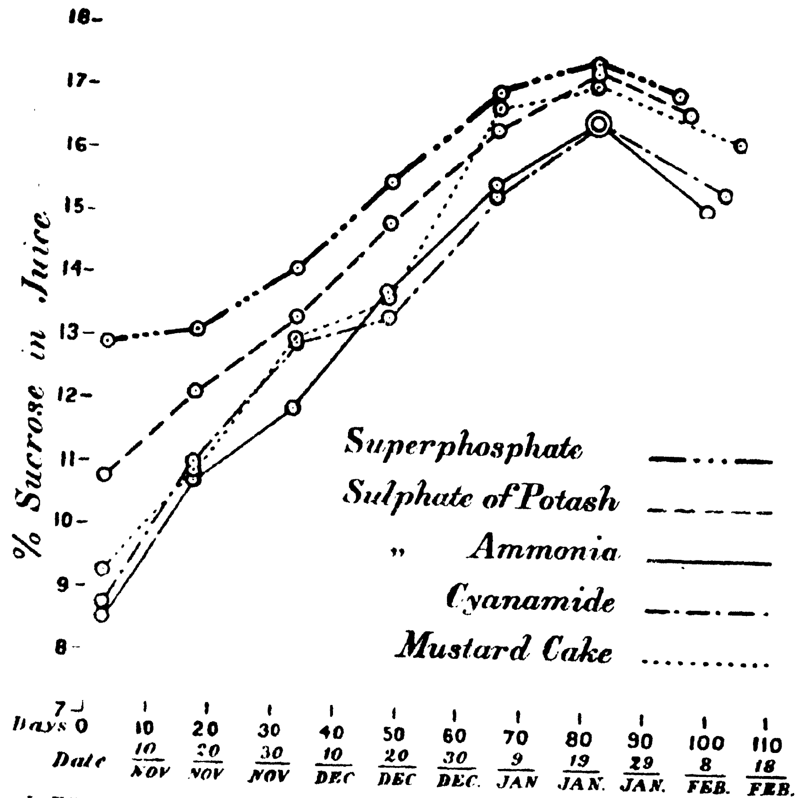

CHART I. Effect of manure on the periodic variation of sucrose in sugarcane juice before harvest.

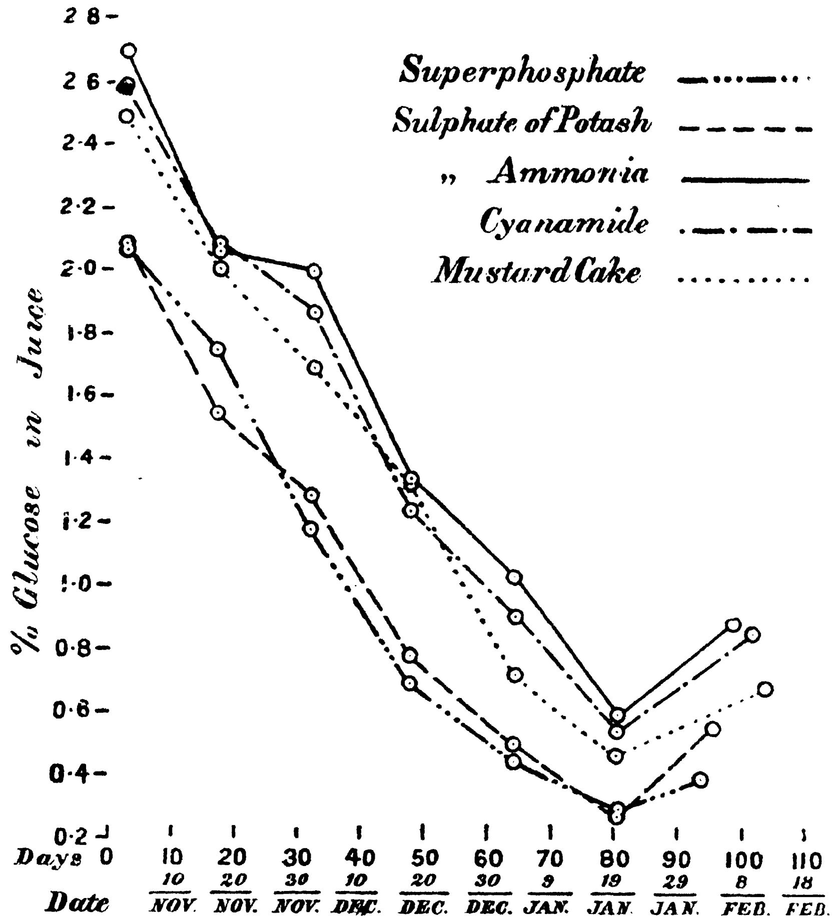

CHART II. Effect of manure on the periodic variation of glucose in sugarcane juice before harvest.

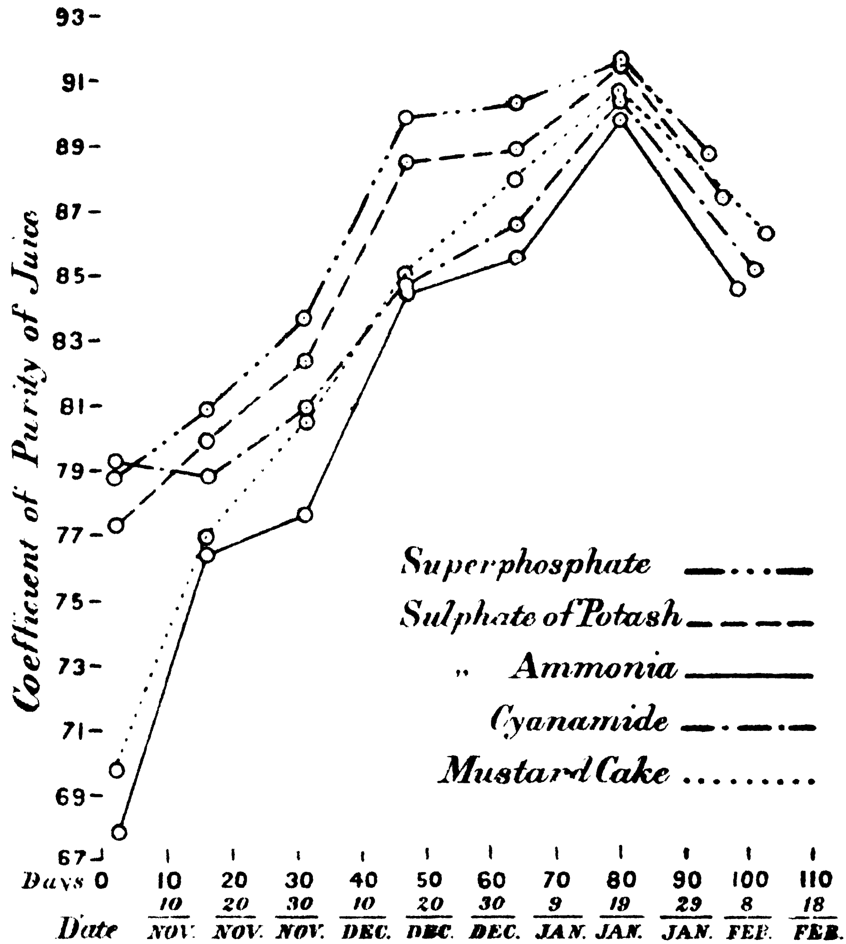

CHART III. Effect of manure on the periodic variation of co-efficient of purity of sugarcane juice before harvest.

These results show that in all the plots the sugarcane attained maturity by the first week of January and maintained the sucrose content of the juice and the purity fairly well till the end of the month. The graphs for sucrose, however, reached the highest points by the end of the third week of January.

It is evident that superphosphate has the greatest influence in producing a juice with the highest purity and sucrose content throughout the whole period. The graphs for the purity of juice and the sucrose content run higher, and the graph for the glucose content lower than all the others. In other words, it may be said that superphosphate has the effect of improving the quality of the juice.

Sulphate of potash also appears to maintain a juice of high purity, whereas sulphate of ammonia gives the lowest graphs for sucrose and purity and the highest one for glucose. The latter manure would, therefore, appear to exert a depressing influence on the quality of the cane.

It is also significant that in the case of both mustard cake and cyanamide similar sucrose graphs were obtained at first but later on the sucrose graphs for mustard cake showed an abrupt rise, while that for cyanamide followed a course similar to one given by sulphate of ammonia. Cyanamide, therefore, like sulphate of ammonia, tends to produce a juice of low quality, whereas mustard cake in the later stages gives an intermediate value.

It may be inferred from these results that P_2O_5 and K_2O tend to produce juice showing a higher quality and sucrose content than do artificial nitrogenous manures. Organic nitrogen in the form of cakes tends to give intermediate values, but in this case the influence of P_2O_5 and K_2O in the cake requires consideration.

Effect of manure on the quality of *gur*.

In order to study the effect of manures on the quality of *gur*, the sugarcane juice from the various plots was clarified by Horne's[1] super-defecation method (simplified) to be described later on, and boiled down in an open pan until the temperature of the thick syrup rose to 113°-114°C. when the process was stopped. Care was taken to keep the conditions of clarification and boiling as uniform as possible. There was, however, some loss of juice with the sediment, the quantity of which varied within small limits and the yields of *gur* therefore are not strictly proportional to the sugar contents of the juices. There was very little inversion of sucrose during the process and in every case the *gur* produced was in the form of hard cake of light brown colour of much higher quality than is produced by the local cultivator.

Samples were drawn from the first cake of *gur* prepared from each plot and analysed and the average results of these analyses are given in the following table together with the average analyses of the juice from which the *gur* was prepared.

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[1] Horne, W. D. Super-defecation of cane Juice. *J. Ind. Engin. Chem*, Vol. XVI, pp. 732-733.

TABLE II.

Effect of manure on the quality of gur.

Plot No.	Manure applied	% *Gur* obtained		Composition of *gur*					Composition of juice from which *gur* was prepared		
		On cane	On juice	% Moisture	% Sucrose	% Glucose	Ratio sucrose/glucose	% Ash	% Sucrose	% Glucose	Purity
1 and 6	Superphosphate	8·12	14·10	9·97	82·47	3·00	27·5	2·88	17·01	0·39	88·68
2 and 7	Sulphate of potash	7·92	13·96	9·83	82·21	2·78	29·6	2·96	16·66	0·56	87·31
3 and 8	Sulphate of ammonia	7·82	13·71	12·63	76·16	5·03	15·1	3·58	15·18	0·88	84·47
4 and 9	Cyanamide of lime	7·79	13·48	12·19	74·89	5·76	13·0	3·25	15·45	0·85	85·04
5 and 10	Mustard cake	7·13	12·70	13·89	76·25	4·45	17·1	3·25	16·23	0·67	86·15

These results show very clearly that the *gurs* obtained from the superphosphate and potash plots are of much higher quality than those from plots manured with nitrogenous manures.

The *gur* produced from the superphosphate plots possessed the highest sucrose content (82·47 per cent.) and the lowest amount of ash (2·88 per cent.), values which are closely followed by the *gur* from the sulphate of potash plot. It is noticeable however that the latter has a slightly higher purity value as measured by the ratio $\frac{\text{sucrose}}{\text{glucose}}$.

The *gurs* from plots manured with artificial nitrogenous manures are comparatively very inferior in quality, yielding ratios ($\frac{\text{sucrose}}{\text{glucose}}$) of only 13 and 15 as compared with 27·5 and 29·5 in the *gurs* from phosphoric acid and potash plots. The mustard cake plot yielded *gur* of similar low quality.

It is also very significant that although the yields of *gur* from several plots did not differ very materially and also that the boiling process was controlled by the temperature attained, the *gurs* from the nitrogenous plots contain a materially larger proportion of water, a point which militates against their keeping qualities.

The conclusion arrived at from a comparison of the different *gurs* are substantially in agreement with those derived from a comparison of the cane juices and may be put in the form that nitrogenous manures tend to produce juices and *gur* of comparatively low quality compared to those produced by the use of phosphate and potash manures. Consequently, in order to obtain the highest quality of *gur* from a given cane nitrogenous manures must be employed with extreme circumspection. Possibly, a solution of the problem of raising the greatest possible yield of cane and at the same time maintaining the maximum quality of juice and *gur* will be attained by employing nitrogenous manures, preferably cakes, in combination with heavy applications of super and potash.

It does not appear that nitrogenous manuring alone will accomplish this aim.

APPENDIX.

Clarification of sugarcane juice by Horne's super-defecation method[1].

A series of trials were undertaken both in the laboratory and on the large scale in February 1926 to prepare a superior quality of *gur* from cane variety Co. 213 by Horne's method. This method aims at securing the advantages of complete precipitation of all the impurities that lime will throw down without suffering the disadvantages of working up a highly alkaline juice. This was accomplished by liming the juice in the cold to slight alkalinity to litmus then heating it to boiling and finally adding a small quantity of phosphoric acid barely sufficient to precipitate the excess of lime.

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[1] *Loc. cit.*

For comparison *gur* was made by a country boiler by the country method and some cakes were produced by him according to special directions. Finally some cakes were produced by Horne's process, certain modification being introduced during the clarification of the juice and in regulating the temperature of the boiling of the juice.

Samples were drawn from the different cakes and analysed. The results are stated below (p. 286).

From the results it will be seen that by the country process a considerable amount of sugar was caramelised (cake No. 1) owing to the high temperature to which the juice was boiled. There was also a good deal of inversion of sucrose owing to the strong acidity of the juice and the high temperature of boiling (cake No. 2).

On liming and taking out scum, inversion of sucrose was prevented to a great extent and the cake obtained was quite hard but its colour was dark which deepened with time.

In the case of the juice clarified by Horne's process the *gur* was comparatively high in purity, its colour was light and it was distinctly crystalline. The mean composition of cakes Nos. 5-8 shows the product to be very superior in quality containing 81·69 per cent. sucrose, 3·4 per cent. glucose and 1·95 per cent. ash. The average quality of *gur* prepared on a field scale by this method in 1927 from Co. 213 from plots treated with different manures is shown by the following average result of its analysis :—

	Per cent.
Sucrose	78·40
Glucose	4·09
Ash	3·18

The additional cost of manufacture of *gur* by Horne's process was calculated to be a rupee per maund of *gur* ; but this is off-set by the higher quality of *gur* produced which commanded a high price on the market. The *gur* produced at Pusa in 1926 was actually sold at Rs. 10 per maund, while the rate for local country *gur* was Rs. 7 to Rs. 8.

TABLE III.

Composition of gur prepared at Pusa in the beginning of February 1926 under different conditions of clarification of juice and temperature of boiling.

Composition	Cake 1 (By country method) unclarified juice boiled to 127°C. scum removed	Cake 2 (By country method) at a lower temperature unclarified juice boiled to 117°C. scum removed	Cake 3 Juice limed and scum removed during boiling and boiled to 117°C.	Cake 4 Juice clarified with lime, excess of lime removed with phosphoric acid and boiled to 117°C.	Cake 5 Juice clarified as in cake 4 and boiled to 114° C.	Cake 6 Juice clarified as in cake 4 and boiled to 114° C.	Cake 7 Juice clarified as in cake 4 and boiled to 114° C.	Cake 8 Juice clarified as in cake 4 and boiled to 114° C.	Average analysis of cake Nos. 5 to 8 (by improved method)
1. % Moisture .	7·60	9·51	9·64	8·74	11·23	8·11	7·79	9·62	9·19
2. % Sucrose .	73·79	77·85	78·36	80·15	82·30	79·87	82·21	82·39	81·69
3. % Glucose .	8·10	10·56	5·90	2·30	4·50	4·50	2·50	2·10	3·40
4. % Ash . .	2·52	2·16	2·33	2·34	1·48	2·31	2·03	1·97	1·95
% Phosphoric acid (P_2O_5)	0·111	0·111	0·099	0·047	0·110	0·210	0·074	0·064	·115
Total of 1, 2, 3 and 4.	92·01	100·08	96·23	93·53	99·51	94·79	94·53	96·08	96·23
Yield of *gur* on juice.	17·54	18·46	18·36	13·82	14·64		13·89		14·26
Yield of *gur* on cane.	9·57	10·00	9·36	6·91	8·05		8·38		8·23

RINGING AND NOTCHING EXPERIMENTS WITH THE MANGO.

BY

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IT is commonly known that the mango generally produces vegetative shoots in two or three distinct flushes during the year about March-April, June-July and October-November.[1] The flowering also similarly takes place twice or thrice from November to March. Every tree does not regularly put forth all the vegetative or floral flushes. Some trees produce leafy growth either wholly or partly for one flush only, while others produce them for two or three of the flushes. Hence, flowering also, which depends much upon the nature of the vegetative growth, is not quite regular. Vegetative shoots of October and November do not generally bear flower heads that season; while of those of the other flushes some bear and some do not. Thus in a particular season it can be seen that there are three types of trees, *viz.*, (1) trees which have fully flowered, (2) trees which have partially flowered and partially produced vegetative shoots, and (3) trees which have produced vegetative shoots only and no flowers. The flowerheads are generally terminal and are often borne on shoots six months or more in age and produce in spite of a large number of flowers one fruit only on an average. With a view to see if the number of flowerheads and consequently of fruit produced can be increased by ringing and notching, experiments were tried during the season of 1926-27, and the results are described in the present note.

METHOD OF RINGING AND NOTCHING.

As it is mostly the mature wood that is capable of producing flowerheads and as notching is known to induce the lower dormant buds to grow,[2] it was thought possible to influence any dormant buds on old wood to develop into flowerheads. Accordingly notching and ringing were tried with a sharp knife above a single or several healthy buds on old shoots within a foot or so from their tip. The ring or notch was about a quarter of an inch in width and penetrated just down to the wood. These trials were made once every month from November to March on the three types of trees described above. Ringing was also tried on old branches which had put forth vegetative shoots in October, just below the fresh growth.

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[1] Burns, W., and Prayag, S. H. The Book of Mango, *Bombay Dept. of Agri. Bull.* 103 (1920).
[2] Cheema, G. S., and Gandhi, S. R. The influence of notching on the yield of the fig trees. *Agri. Jour. India*, Vol. XVIII, Part V.

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Results.

The results have been of considerable interest. The ring or the notch had a different effect in each of the three types of trees described. In the case of the tree fully flowered, the ring induced a number of the dormant buds below to develop into flowerheads—within about three weeks from the date of operation. The number of the flowerheads depends upon the number of the healthy buds present and on one branch as many as eleven of them were formed. Notching, however, produced one flowerhead only. These flowerheads developed normally and produced fruits just like the others. But on account of the larger number of flowerheads produced per branch by ringing more fruits, were obtained. Thus some of the ringed branches gave even four or five fruits, where ordinarily only about one fruit would have been obtained at the end of one flowershoot. The ringing and notching did not prevent the development of the terminal buds wherever they were healthy. But they were not so vigorous and the fruits produced were much smaller in size.

On trees that had produced only vegetative shoots and no blossoms at all, the ringed and notched buds did not usually develop. Where they did so, they gave rise to vegetative shoots only.

On trees which have only flowered partially, the results were quite different. In this case the flowering may be found to be scattered all over the tree or restricted to particular branches only. In the former case ringing mostly succeeds in producing flowerheads even from branches which have put forth fresh vegetative shoots in October. In the latter, if the ringed branches happen to lie on the blossomed side, they behave just like those on a fully blossomed tree described above ; while if they happen to lie on the vegetative side, they behave like those on a tree which has not blossomed at all.

The trials were repeated from November to March but were only successful in the first three months, *viz.*, November, December and January. From February onwards the ringed buds on all trees either did not develop or produced only vegetative growth.

Theory.

Physiologists seem to differ very much in their views regarding the exact effect of the operation of ringing on the physiology of the plant. Gandhi[1] and Furtado[2] have tried to explain the views of different workers on the subject from the beginning up to date. The most modern idea is that notching or ringing in the bark brings about an interruption in the transpiration stream and thus helps them to sprout. But the question as to why they are sometimes vegetative and sometimes flowershoots still remains very obscure. But it does not seem clear that there is some definite

[1] Gandhi, S. R. Investigations in fig culture and treatment. *Bombay Dept. Agri. Bull.* 117 of 1924.

[2] Furtado, C. X. Theory of notching. *Poona Agri. College Mag.*, September 1925.

Fig. 1. Two fruits developing below the ring.

Fig. 2. Two fruits developing below the ring; the terminal flowerhead has also produced a fruit.

EFFECT OF RINGING ON OLD SHOOTS OF A MANGO TREE.

PLATE XXV.

Effect of a notch on an old shoot of a mango tree which produced fresh vegetative growth in October. One flowerhead was produced which developed one fruit.

condition in the shoots which bear flowers, which differentiate them from those which cannot be made to do so. Whether this is a special chemical substance or not is at present quite unknown, but the existence of some such condition is certain. Where it exists, ringing and notching seem to be one of the means of causing it to be effective in a particular case.

Conclusions.

(1) Notching and ringing on mature wood in the mango tree help the development of the lower bud or buds into flowerheads on trees which are flowering fully and on some trees which are partially flowering as described above.

(2) If these operations are tried on trees that have produced only vegetative shoots or such branches of a partially flowering tree as have not produced flowers the bud or buds do not develop at all or develop into vegetative shoots.

(3) The flowerheads developed by ringing or notching behave just like the other flowerheads naturally produced but the fruits from the terminal flowerheads are smaller in size.

(4) Notching and ringing help to increase the yield by giving rise to a larger number of flowerheads than those naturally produced especially from the branches that are dormant and those that have put forth fresh vegetative growth which is not likely to produce any flowerheads during the same season.

(5) The removal of the bark in ringing or notching does not harm the trees in any way as the wounds heal up in the course of two or three months.

SELECTED ARTICLE.

CORRELATIONS OF SEED, FIBRE AND BOLL CHARACTERS IN COTTON.*

BY

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INTRODUCTION.

The purpose of this contribution is to bring together in convenient form information in regard to the correlations existing among the characters of the bolls, seeds and fibre of cotton. Numerous determinations have been made at the United States field station, Sacaton, Ariz., chiefly on Pima and other varieties of the Egyptian type, but also on a second generation population of a hybrid between Upland and Egyptian cottons. The data obtained in Arizona are supplemented by reference to the published data of other investigators who worked chiefly with Upland cottons.

With the exception of the above-mentioned hybrid, the material on which the correlations were determined was more or less homogeneous, hence not suitable for revealing such linkages as may exist among the characters considered. It was sought to ascertain the physical and physiological interrelations of characters that are of practical importance in cotton breeding, but the data thus obtained should be useful for comparison in future genetic studies.

All correlations were determined by the product-moment method.

CORRELATIONS DETERMINED ON INDIVIDUAL BOLLS OF PIMA COTTON.

The population comprised 50 plants scattered through two plots of the commercial stock of Pima cotton at Sacaton in 1925. Ten characters were determined on from two to five bolls on each plant, only 3-lock bolls being used. Boll length, boll diameter, and boll index were determined on 250 bolls and the other characters on 224 bolls. Each boll was tagged when measured. The external dimensions were measured on bolls judged to be fully developed although still closed. The length and the maximum diameter of the boll were measured with specially designed calipers (Figs. 1 and 2). To check the first measurements, many of the bolls were measured again two weeks later, but as the second series was incomplete, the first measurement was used in plotting the correlations, except in 14 cases where the second measurement showed a noteworthy increase in one or both dimensions. When these bolls had opened naturally, the dry seed cotton was gathered and was weighed on a chemical balance. The content of each boll was then ginned separately and the weight of the seeds was determined. The weight of the fibre was determined by subtraction.†

* Reprinted from *Jour. Agri. Res.*, Vol. 33, No. 8.

† The determinations of all characters were made by George J. Harrison, Robert H. Peebles, and Dow D. Porter.

All correlations were plotted on the basis of determinations on the same individual bolls; hence the number was in each case 224, except in the correlations of boll length with boll diameter, boll length with boll index, and boll diameter with boll length, in which the number was 250. Computations by the product-moment method were made of all possible correlations of the nine characters seed-cotton weight per boll, fibre weight per boll, lint percentage, lint index, number of seeds per boll, mean weight of the individual seeds, boll length, boll diameter, and boll index. The coefficients of correlation are given in Table I.

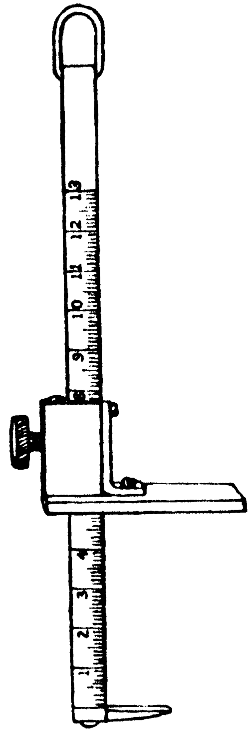

FIG. 1. Caliper (designed by W. G. Wells) for measuring the length of cotton bolls without detaching them from the plant. The fixed arm is placed so that the base of the boll rests upon its thin edge and the adjustable plate is moved along the vertical bar (scaled in millimeters) until it rests lightly upon the tip of the boll. The screw is then tightened and the reading is taken.

Seed-cotton weight per boll shows, as would be expected, very high positive correlations with fibre weight per boll and number of seeds per boll. It is also positively and very significantly but not very highly correlated with the external length and diameter of the boll, hence it may be concluded that these external measurements of the fully developed but unopen boll give only a fair indication of the weight of its matured contents. Still lower are the positive correlations of seed cotton weight with lint percentage and lint index, yet both are significant (r/E 5·8 and 9·0). The occurrence of positive correlations in these cases probably signifies that favourable conditions, conducive to the development of heavy bolls, are also conducive to a greater increase in the weight of fibre than of seed.

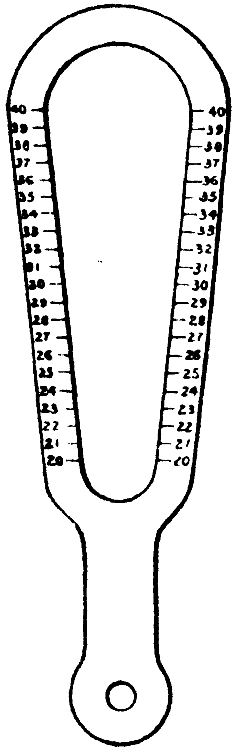

FIG. 2. Caliper (designed by E. C. Chilcott and L. J. Briggs) for measuring the diameter of cotton bolls without removing them from the plant. The angle formed by the diverging sides of the loop and the calibration of the intervals (millimeters) marked on them are so calculated that when the loop is placed horizontally over the boll at its point of greatest diameter and is pushed forward (from the handle) as far as possible without compressing the boll, the maximum diameter of the boll is indicated by the figure on the scale at the point with which the side of the boll is in contact.

Fibre weight per boll is similar to seed-cotton weight in its correlations with other characters. The high positive correlation of fibre weight with number of seeds per boll shows the importance of the degree of fertilization as a factor in the yield of cotton (*6, 7, pp. 49—50*).*† As would be expected, fibre weight is more closely correlated than seed-cotton weight with lint percentage and lint index.

Table I.

Correlations of seed, fibre and boll characters determined on 224 or 250 individual bolls from 50 plants of Pima cotton, Sacaton, 1925.

	Seed cotton weight per boll	Fibre weight per boll	Lint per-centage	Lint index	Num-ber of seeds per boll	Mean weight of indivi-dual seeds	Boll length	Boll dia-meter	Boll index
Seed-cotton weight per boll.	...	0·858 ±	0·244 ±	0·352 ±	0·757 ±	0·105 ±	0·418 ±	0·546 ±	0·008 ±
	...	·012	·042	·039	·019	·045	·037	·032	·045
Fibre weight per boll	0·858 ±	...	·602 ±	·542 ±	·700 ±	—·104 ±	·415 ±	·445 ±	·093 ±
	·012	...	·029	·032	·023	·045	·037	·036	·045
Lint percentage (*a*).	·244 ±	·602 ±	...	·540 ±	·284 ±	·432 ±	·179 ±	·074 ±	—·142 ±
	·042	·029	...	·032	·041	·036	·044	·045	·044
Lint index (*b*).	·352 ±	·542 ±	·540 ±	...	—·073 ±	·379 ±	·237 ±	·228 ±	—·100 ±
	·039	·032	·032	...	·045	·038	·042	·042	·045
Number of seeds per boll.	·757 ±	·700 ±	·284 ±	—·073 ±	...	—·433 ±	·310 ±	·380 ±	—·041 ±
	·019	·023	·041	·045	...	·036	·041	·038	·045
Mean weight of individual seeds.(*c*)	·105 ±	—·104 ±	—·432 ±	·379 ±	—·433 ±	...	·059 ±	·189 ±	·076 ±
	·045	·045	·036	·038	·036	...	·045	·043	·045
Boll length	·418 ±	·415 ±	·179 ±	·237 ±	·310 ±	·059 ±	...	·385 ±	—·680 ±
	·037	·037	·044	·042	·041	·045	...	·038	·023
Boll diameter	·546 ±	·445 ±	·074 ±	·228 ±	·380 ±	·189 ±	·385 ±	...	·325 ±
	·032	·036	·045	·042	·038	·043	·038	...	·040
Boll index (*d*).	·008 ±	·093 ±	—·142 ±	—·100 ±	—·041 ±	·076 ±	—·680 ±	·325 ±	...
	·045	·045	·044	·045	·045	·045	·023	·040	...

(*a*) Weight of fibre as a percentage of the weight of seed cotton.
(*b*) Weight of fibre × 100 divided by the number of seeds.
(*c*) Weight of seeds divided by number of seeds.
(*d*) Maximum diameter as a percentage of the length.

* Reference is made by number (italic) to "Literature cited," p. 796.

† Counts of the number of ovules in 3-celled ovaries of Pima cotton, made at Sacaton in 1921 on 250 ovaries, showed a range of from 15 to 24, and a mean of 20·6 × 0·09 (*1, p. 51*). Since determinations at two localities in 1922 gave means of 20·8 and 21·5, it may be assumed that the true mean number of ovules in 3-celled ovaries of this variety is 21. The 224 three-lock bolls of Pima cotton in 1925 showed a range of from 8 to 23 seeds per boll, the mean having been 17·6 × 0·13. This mean indicates that 84 per cent. of the ovules had been fertilized under the exceptionally favourable conditions for cotton pollination prevailing at Sacaton. As would be expected, there was greater variation in the number of seeds than in the number of ovules, the standard deviations having been, for seeds in 1925, 2·853 × 0·091 and for ovules in 1921, 2·180 × 0·066. The difference amounts to 31 per cent. and is six times its probable error.

Lint percentage shows a positive and very significant but far from perfect correlation with lint index, and we may conclude that the weight of the seeds is almost if not quite as important as the abundance of the fibre in determining the lint percentage (*1*, *5*). The occurrence of a positive correlation (r 0·284) between lint percentage and number of seeds per boll, with a coefficient seven times its probable error, might be regarded as a consequence of the positive correlation of similar magnitude between lint percentage and weight of seed-cotton per boll, the latter character in turn being highly positively correlated with number of seeds per boll. The partial correlation of lint percentage with number of seeds *constant* for weight of seed cotton gives, however, a coefficient that is still significant (r 0·156$\pm$0·044), indicating that there is some association of high lint percentage with a large number of seeds, independent of the other correlations mentioned and in spite of the fact that in this population weight of fibre per seed (lint index) is not significantly correlated with number of seeds.

Lint percentage shows a fairly high and very significant negative correlation with mean weight of the seeds. The lint percentage is not significantly correlated with boll diameter, but with boll length it shows a slight but probably significant positive correlation (r/E 4·1) which doubtless accounts for the low negative correlation of lint percentage with boll index (r/E 3·2).

Lint index, unlike the lint percentage, is not significantly correlated in this material with number of seeds per boll, hence it may be concluded that the weight of the fibre borne by the individual seed is not affected by the number of seeds in the boll. On the other hand, there is a fairly high and very significant positive correlation between lint index and mean weight of the individual seeds.* There are significant positive correlations of nearly equal magnitude between lint index and the external length and diameter of the boll (r/E 5·6 and 5·4). In other words, the larger bolls tend to have a greater abundance of fibre on the individual seeds, but why this relation obtains is not clear. Unless there is a linkage involved, it probably expresses merely a like effect of environmental conditions on characters that are entirely independent.

Number of seeds per boll, in addition to the correlations already mentioned, shows a fairly high and very significant negative correlation with mean weight of the individual seeds, and is positively and very significantly correlated with boll length and boll diameter (r/E 7·6 and 10·0).

Boll length is positively and very significantly correlated with boll diameter; in other words, large bolls tend to be large in both dimensions and *vice versa*. The higher positive correlation than 0·385 might have been expected.

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* The reality of this correlation is shown by the fact that when both fibre weight per boll and number of seeds per boll are held constant, the coefficient of partial correlation is 0·244$\pm$0·042 (r/E 5·8) which is not significantly lower than the coefficient of the original correlation of lint index with mean weight of the seeds (r 0·379$\pm$0·038).

Boll index, an expression of the shape of the boll, shows no correlation with other characters except the expected ones with its components boll length and diameter, the unimportance of the low negative correlation with lint percentage having been pointed out.

It was thought possible that the external length and diameter of the boll when integrated would show a higher positive correlation with weight of the contents (seed-cotton weight) than either external measurement taken separately. The correlations of seed-cotton weight with boll length *plus* the diameter and boll length *plus* twice the diameter, therefore were computed, and the values found for r were $0{\cdot}518 \pm 0{\cdot}033$ and $0{\cdot}582 \pm 0{\cdot}030$. Neither coefficient differs significantly from that of the correlation seed-cotton weight with boll diameter (r $0{\cdot}546 \pm 0{\cdot}032$).

The correlation between lint index and grade of seed fuzziness also was computed, and gave a value for r of only $0{\cdot}012 \pm 0{\cdot}045$.* Very smooth seeded varieties of cotton tend to have sparse lint and the same appears to be true in general of such exceptionally smooth seeded individuals of the Pima variety as grade only 1 or 2 in seed fuzziness.† But the 50 plants of the commercial stock of Pima which furnished the material for this correlation all had more or less fuzzy seeds (grades 4 to 9), and within a population of a single variety having this range of fuzziness there appears to be no relation between the abundance of short fibres (fuzz) and of long fibres (lint).

Comparison of correlations based on individual bolls and on the means of samples consisting of numerous bolls.

Correlations of eight pairs of characters were determined in 1925 on two lots of bolls of the commercial stock of Pima cotton: (A) 224 individual bolls borne on 50 plants growing in the same field at Sacaton and (B) 25 samples from as many fields in the Salt River Valley, each sample comprising 100 bolls, each boll from a different individual plant. For the 224 bolls (series A) as mentioned in the preceding section, each character was determined separately on each individual boll. For the 25 samples (series B) the mean seed-cotton weight, fibre weight and number of seeds per boll were obtained by dividing the total weight or number in the sample by 100. Lint percentage was obtained by dividing the total fibre weight by the total seed-cotton weight of the sample. Lint index was obtained by multiplying the total fibre weight of the sample by 100 and dividing by the total number of seeds. Mean weight of the individual seeds is the total weight of seeds in the sample divided by the total number of seeds.

Table II gives, for both populations, the statistical constants of the characters involved in the correlations. The coefficients of correlation are given in Table III.

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*This correlation was determined in Arizona also on 180 F_2 plants of an Upland-Pima hybrid in 1919, on 178 plants of Pima cotton in 1922, and on 36 plants of Sakellaridis cotton in 1922. In no case was the coefficient significant.

† A case of linkage between naked seeds and sparse lint and *vice versa* is reported by Thadani (*13*).

Table II.

Statistical constants of the characters involved in correlations determined on (A) 224 individual bolls of Pima cotton and on (B) 25 samples of 100 bolls, each of Pima cotton.[a]

Character		Mean	Standard deviation of the mean
Seed-cotton weight per boll (grams)	A	3·15 ± 0·023	0·504 ± 0·016
	B	3·36 ± ·054	·397 ± ·038
Fibre weight per boll (grams)	A	·87 ± ·088	·178 ± ·006
	B	·93 ± ·016	·117 ± ·011
Number of seeds per boll	A	17·6 ± ·13	2·853 ± ·091
	B	17·9 ± ·22	1·648 ± ·016
Mean weight of individual seeds (grams)	A	·129 ± ·0006	·0143 ± ·0005
	B	·135 ± ·0008	·0062 ± ·0006
Lint index (grams)	A	4·94 ± ·029	·635 ± ·020
	B	5·18 ± ·035	·258 ± ·024

(a) The standard deviations and probable errors of the means of series B have been corrected for the number (25).

Table III.

Coefficients of correlation in two series of samples of Pima cotton, 1925, these being (A) 224 individual bolls (B) 25 samples of 100 bolls each.

Character pair		Coefficient of correlation	Character pair		Coefficient of correlation
Seed-cotton weight per boll and lint index.	A	0·352 ± 0·039	Fibre weight per boll and mean weight individual seeds.	A	−·104 ± ·045
	B	·590 ± ·088		B	·435 ± ·109
Seed-cotton weight per boll and number of seeds per boll.	A	·757 ± ·019	Lint index and number of seeds per boll.	A	−·073 ± ·045
	B	·934 ± ·017		B	·436 ± ·109
Fibre weight per boll and lint index.	A	·542 ± ·032	Lint index and mean weight individual seeds.	A	·379 ± ·038
	B	·721 ± ·065		B	·357 ± ·117
Fibre weight per boll and number of seeds per boll.	A	·700 ± ·023	Number of seeds per boll and mean weight individual seeds.	A	−·433 ± ·036
	B	·881 ± ·030		B	·396 ± ·114

The standard deviation of every character (Table II) was greater in Series A (224 individual bolls) than in Series B (25 samples of 100 bolls each) as would be expected since in the latter series the units are averages.

The correlations of seed-cotton weight and of fibre weight per boll with lint index and with number of seeds per boll are in the same direction in both series, but in every case the correlation appears to be closer in Series B. For the correlation of lint index (mean weight of fibre per seed) with mean weight of the individual seed, the coefficients for the two series are nearly identical. The correlations of fibre weight per boll with mean weight of the individual seeds, lint index with number of seeds per boll and number of seeds per boll with mean weight of the individual seeds gave coefficients in the two series which were of opposite sign and differed by an amount not less than 0·5.

As to the significance of the differences between the coefficients of correlation of the two series given in Table III, it should be noted that the probable errors of the coefficients of correlation were computed by the usual formula $\left(\frac{0{\cdot}6745\times(1-r^2)}{\sqrt{n}}\right)$. The number of samples in series B was only 25, and it has been shown recently by Fisher (3) that the probable errors of coefficients of correlation based on small numbers are too low when computed by this formula. Fisher's method of "transformed correlations" (*3, p. 161–169*) therefore has been used in determining the significance of the differences between the coefficients of series A and B. The differences as thus computed are shown in Table IV.

TABLE IV.

Significance of differences between the coefficients of correlation obtained on the two series of samples, A and B, as determined by the method of "transformed correlations."

Correlation	Difference between transformed correlations (z)	D/E
Seed-cotton weight per boll with lint index	0·31 ± 0·223	1·4
Seed-cotton weight per boll with number seeds per boll	·70 ± ·223	3·1
Fibre weight per boll with lint index	·30 ± ·223	1·3
Fibre weight per boll with number seeds per boll	·51 ± ·223	2·3
Fibre weight per boll with mean weight of seeds	·57 ± ·223	2·6
Lint index with number seeds per boll	·54 ± ·223	2·4
Lint index with mean weight of seeds	·03 ± ·223	0·1
Number seeds per boll with mean weight of seeds	·88 ± ·223	3·9

Application of this method of transformed correlations brought out differences between the correlations in the two series of samples that were probably significant

in only two cases, seed-cotton weight with number of seeds per boll (D/E 3·1) and number of seeds per boll with mean weight of the individual seeds (D/E 3·9). The latter case is particularly interesting since the coefficients were of opposite sign and of nearly equal magnitude. In Series A the coefficient of the partial correlation of number of seeds per boll with mean weight of the individual seeds *constant* for fibre weight per boll (r—0·505 ± 0·034) does not differ significantly from that of the original correlation (r—0·433 ± 0·036). In Series B the original correlation (r 0·396 ± 0·114) disappears in the partial correlation *constant* for fibre weight per boll (r 0·030 ± 0·135). It is probable therefore that the apparently significant positive correlation in series B between the number and the mean weight of the seeds is conditioned by the very high positive correlation in this material between number of seeds and fibre weight per boll (r 0·881 ± 0·030 as compared with 0·700 ± 0·023 in Series A). The coefficients of the two series for the partial correlation of number of seeds per boll with mean weight of the individual seeds *constant* for fibre weight per boll do not differ significantly when compared as transformed correlations, the difference being only 0·43 ± 0·223.

Conceivably, however, there might have been a real difference between the two series in the direction of the correlation between number of seeds per boll and mean weight of the individual seeds, if, in Series B, in which the characters were positively correlated, both number and weight of the seeds had been affected in a like direction by the conditions, favourable or unfavourable, in the 25 fields in Salt River Valley from which the 25 samples were taken. The diversity of conditions among these fields was much greater than the diversity within the field at Sacaton in which the 224 bolls of series A were collected.* A physiological tendency to decreasing weight of the individual seeds as their number in the boll increases may be assumed as the cause of the negative correlation in Series A, the effect of which tendency, if present also in Series B, may have been overcome by the greater influence of very diverse environmental conditions.

The data given in Table III shows clearly the danger of generalizing concerning the correlation of characters on the basis of a coefficient determined on a single population or under one set of conditions. The two populations here compared were of the same variety and were grown in the same year, yet for three pairs of

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* Comparison of the standard deviations in Table II would suggest, on the contrary, that Series A had been subjected to a greater diversity of environment than Series B. But, as already mentioned, the units from which the statistical constants were computed were individual bolls in Series A and averages of 100 bolls in Series B. Hence comparison of the standard deviations of A and B is valueless as an indication of the relative diversity of the environments to which the two series had been exposed, for the standard deviations of Series B represent merely the variation from field to field and do not take account of the variation within each of the 25 fields which, presumably, was of the order of magnitude indicated by the standard deviations of Series A. If the 25 samples of 100 bolls each of Series B could be regarded merely as multiplications of the one sample of 224 bolls constituting Series A, the standard deviation of Series B should have been only about one-tenth the observed standard deviation of Series A. On this assumption, the standard deviations of Series B for the several characters as given in Table II, are from 4 to 8 times the values that would have been obtained if the 2,500 bolls of Series B had constituted a population as homogeneous as the 224 bolls of Series A.

characters they yielded coefficients of opposite sign. Analysis indicated that in this case the differences probably were not significant, but it is conceivable that significantly different coefficients of correlation might be given by subpopulations one of which had been subjected to a relatively uniform and the other to a very diverse environment.

Synopsis of all correlations determined in Arizona.

In addition to the two series of correlations determined in 1925 and discussed, in the preceding sections, numerous correlations among the same and other boll, seed and fibre characters had been determined in Arizona in previous years, chiefly on cottons of the Egyptian type but also on 180 F_2 plants of an Upland-Egyptian hybrid grown at Sacaton in 1919 (*8*). It seems desirable therefore to bring together all available data on the correlation of each pair of characters, supplementing the Arizona data with references to correlations determined by other investigators working with cottons of the Upland type.*

The order in which the correlations are arranged is indicated by the following list of subjects :—

1. Seed-cotton weight per boll.
2. Fibre weight per boll.
3. Seed weight per boll.
4. Number of seeds per boll.
5. Mean weight of individual seeds.
6. Lint percentage.
7. Lint index.
8. Fibre length.
9. Fibre color.
10. Seed fuzziness.
11. Boll length.
12. Boll diameter.
13. Boll index.
14. Boll apex index.
15. Boll volume.

In the case of the Upland-Egyptian hybrid two different lots of material were used. The boll characters length, diameter, index, and apex index were determined on one unopen boll from each plant and the seed and fibre characters lint index, seed fuzziness, fibre length, and fibre color were determined on the contents of five matured bolls from each plant. Consequently, only the correlations among the four boll characters and the correlations among the four seed and fibre characters will be considered in this section.

As to the units on which are based the correlations in Egyptian cottons, for characters 1 to 10 these were single bolls in only one series of samples, the 224 Pima bolls of 1925. In all other series, the units were the means of several bolls, each

* The most comprehensive data hitherto published on correlations of boll, seed, and fibre characters of cotton are those of :

Hodson (*4*), who determined correlations on from 34 to 85 individual plants of 2 different varieties in 1911 to 1917, on 48 varieties in 1917, and on 87 varieties in 1918. It may be inferred that in the last two series varietal means were the units in plotting the correlations.

Dunlavy (*2*), whose correlations were based on from 127 to 167 individual plants in Texas.

Martin and Mason (*10*), whose correlations were based on 811 individual plants in Nigeria.

Stroman (*12*), who determined correlations for each of 16 varieties in Texas, using 50 plants of each variety.

The units employed by the investigators cited in computing the correlations were not individual bolls but individual plants or varietal means.

lot of bolls representing either a different individual plant or a different field. In a few cases the means of progenies, each progeny comprising several individual plants, were the units employed in computing the correlations. For characters 11 to 15 the units on which the correlations are based were in nearly all cases determinations made on single bolls (one per plant).

Seed-cotton weight per boll with fibre weight per boll. The expected high and very significant positive correlation was shown by 224 individual bolls of Pima cotton in 1925 (r 0·858 ± 0·12).

Seed-cotton weight per boll with number of seeds per boll. High and very significant positive correlation was shown in 1925 by 224 individual bolls of Pima cotton (r 0·757 ± 0·019) and by 25 samples of 100 bolls each of Pima cotton (r 0·934 ± 0·017).

Seed-cotton weight per boll with mean weight of individual seeds. Not significantly correlated in 224 individual bolls of Pima cotton in 1925 (r 0·105 ± 0·045). Dunlavy (*2*) found a high, positive, and very significant correlation (r 0·664 ± 0·034) in Upland cotton between what he terms "boll size" (weight of seed-cotton per boll) and mean seed weight, and Hodson (*4*) in four populations of Upland cottons obtained coefficients ranging from 0·506 ± 0·086 to 0·832 ± 0·030.

Seed-cotton weight per boll with lint percentage. A low but apparently significant positive correlation was shown by 224 individual bolls of Pima cotton in 1925 (r 0·244 ± 0·042), while Dunlavy (*2*) records a significant negative correlation in Upland cotton (r —0·394 ± 0·051). Hodson (*4*) determined this correlation in five populations of Upland cotton and got significant coefficients in only two cases, one positive (r 0·395 ± 0·061) and one negative (r —0·455 ± 0·092).

Seed-cotton weight per boll with lint index. Positive and significant correlation was shown in 1925 by 224 individual bolls of Pima cotton (r 0·352 ± 0·039) and by 25 samples of 100 bolls each of Pima cotton (r 0·590 ± 0·088). Three other populations of Pima cotton in 1923 and 1924 gave coefficients of 0·502 ± 0·082, 0·515 ± 0·068 and 0·588 ± 0·072. Dunlavy (*2*) obtained in Upland cotton a coefficient of 0·480 ± 0·046.

Seed-cotton weight per boll with fibre length. This correlation was not determined in Arizona, but Hodson (*4*) reports for five samples of Upland cottons coefficients ranging from 0·030 ± 0·115 to 0·300 ± 0·067, and Dunlavy (*2*), who uses the term "boll size" for seed-cotton weight, got a coefficient for Upland cotton of 0·214 ± 0·057.

Seed-cotton weight per boll with percentage 5-lock bolls per plant. As determined by Dunlavy (*2*) on Upland cotton, a rather high positive correlation was shown (r 0·533 ± 0·058).

Seed-cotton weight per boll with boll length. A positive and very significant correlation was shown by 224 individual bolls of Pima cotton in 1925 (r 0·418 ± 0·037).

Seed-cotton weight per boll with boll diameter. A positive, very significant, and fairly high correlation was shown by 224 individual bolls of Pima cotton in 1925 (r 0·546 ± 0·032).

Seed-cotton weight per boll with boll index. Among the 224 individual bolls of Pima cotton in 1925 there was no correlation between weight of the matured contents of the boll and shape of the fully developed but unopen boll as indicated by its maximum diameter relative to its length (r 0·008 ± 0·045).

Fibre weight per boll with seed weight per boll. As would be expected, a very high and very significant positive correlation was shown by 25 samples of 100 bolls each of Pima cotton in 1925 (r 0·865 ± 0·034). The partial correlation *constant* for number of seeds gave a coefficient of only 0·250 ± 0·126, indicating that the number of seeds in the boll rather than their individual weight determines the correlation with fibre weight.

Fibre weight per boll with number of seeds per boll. High and very significant positive correlation was shown in 1925 by 224 individual bolls of Pima cotton (r 0·700 ± 0·023) and by 25 samples of 100 bolls each of Pima cotton (r 0·881 ± 0·030). Three populations of Pima cotton in 1920 and 1923 gave coefficients of 0·48 ± 0·11, 0·571 ± 0·034 and 0·628 ± 0·039.

Fibre weight per boll with mean weight of individual seeds. No significant correlation was shown by 224 individual bolls of Pima cotton in 1925 (r—0·104 ± 0·045), but 25 samples of 100 bolls each of Pima cotton in 1925 gave a coefficient of 0·435 ± 0·109. It has been shown, however (Table IV) that owing to the small number of the latter series, these coefficients probably do not differ significantly. The apparent correlation shown by the 25 samples doubtless is due to the high correlation between fibre weight and number of seeds per boll (r 0·88 ± 0·03) since the partial correlation of fibre weight per boll with mean weight of seeds *constant* for number of seeds per boll gave a coefficient of only 0·198 ± 0·129.

Fibre weight per boll with lint percentage. A rather high and very significant positive correlation was shown by 224 individual bolls of Pima cotton in 1925 (r 0·602 ± 0·029).

Fibre weight per boll with lint index. Fairly high and very significant positive correlation was shown in 1925 by 224 individual bolls of Pima cotton (r 0·542 ± 0·032), and a still higher correlation by 25 samples of 100 bolls each of Pima cotton (r 0·721 ± 0·065). The partial correlation *constant* for number of seeds per boll increases the coefficient of the first series to 0·830 ± 0·014 and that of the second series to 0·790 ± 0·051. Twelve samples of Pima cotton from as many fields in Salt River Valley in 1920 gave a correlation between fibre weight per boll and lint index of 0·90 ± 0·03.

Fibre weight per boll with boll length. The correlation shown by 224 individual bolls of Pima cotton in 1925 (r 0·415 ± 0·037) was almost identical with the correlation in the same material between seed-cotton weight and boll length.

Fibre weight per boll with boll diameter. The correlation shown by 224 individual bolls of Pima in 1925 (r 0·445 ± 0·036) was lower but not significantly lower than the correlation between seed-cotton weight and boll diameter.

Fibre weight per boll with boll index. As in the case of seed-cotton weight per boll with boll index, no significant correlation was shown by 224 individual bolls of Pima cotton in 1925 (r 0·093 ± 0·045).

The correlation of fibre weight per boll with seed-cotton weight per boll has been mentioned under the latter character as subject.

Seed weight per boll with number of seeds per boll. As would be expected, these characters are very closely correlated, the coefficient for 25 samples of 100 bolls each of Pima cotton in 1925 having been 0·934 ± 0·017.

Seed weight per boll with lint percentage. Two series of samples of Egyptian cotton grown in Arizona in 1910 (5) showed the expected negative correlation (r—0·63 ± 0·047 and — 0·40 ± 0·092).

The correlation of seed weight per boll with fibre weight per boll has been mentioned under the latter character as subject.

Number of seeds per boll with mean weight of individual seeds. A fairly high and very significant negative correlation was shown by 224 individual bolls of Pima cotton in 1925 (r—0·433 ± 0·036), while a positive correlation of nearly equal magnitude was shown by 25 samples of 100 bolls each of Pima cotton in 1925 (r 0·396 ± 0·114). As was suggested on a preceding page, this difference probably is not significant.

Number of seeds per boll with lint percentage. A rather low but significant positive correlation was shown by 224 individual bolls of Pima cotton in 1925 (r 0·284 ± 0·041).

Number of seeds per boll with lint index. These characters were not significantly correlated in 224 individual bolls of Pima cotton in 1925 (r—0·073 ± 0·045), but an apparently significant positive correlation was shown by 25 samples of 100 bolls each of Pima in 1925 (r 0·436 ± 0·109). It has been shown, however (Table IV), that when allowance is made for the small number in the second series, the difference between the two coefficients is not significant. In the 25 samples, the apparent correlation probably was due to the high positive correlation between fibre weight and number of seeds per boll (r 0·88 ± 0·03), since the partial correlation of number of seeds per

boll with lint index, *constant* for fibre weight per boll, gave a very significant negative coefficient (r —0·607 ±0·085). The same partial correlation for the 224 individual bolls gave a coefficient of —0·750 ±0·020.

Number of seeds per boll with boll length. A rather low but quite significant positive correlation was shown by 224 individual bolls of Pima cotton in 1925 (r 0·310 ±0·041).

Number of seeds per boll with boll diameter. A very significant positive correlation was shown by 224 individual bolls of Pima cotton in 1925 (r 0·380 ±0·038).

Number of seeds per boll with boll index. There was no correlation between number of seeds and shape of the boll, as represented by its maximum diameter relative to its length (boll index) in 224 individual bolls of Pima cotton in 1925 (r —0·041 ±0·045).

The correlations of number of seeds per boll with seed-cotton weight per boll, fibre weight per boll, and seed weight per boll have been mentioned under those characters as subjects.

Mean weight of individual seeds with lint percentage. A fairly high and very significant negative correlation was shown by 224 individual bolls of Pima cotton in 1925 (r — 0·432 ±0·036). In Upland cotton Dunlavy (*2*) found a very significant negative correlation (r — 0·529 ±0·038) as did also Martin and Mason (*10*) who obtained a coefficient of —0·34 ±0·021. Hodson (4) found a significant correlation (r — 0·40 ±0·08) in only one of four populations of Upland cottons.

Mean weight of individual seeds with lint index. A fairly high and very significant positive correlation was shown by 224 individual bolls of Pima cotton in 1925 (r 0·379 ±0·038) and an almost identical degree of correlation by 25 samples of 100 bolls each of Pima cotton in 1925 (r 0·357 ±0·117). A much closer association of weight of the seed and weight of the fibre borne on it (lint index) is reported by Dunlavy (*2*) for the Upland cotton with which he worked (r 0·704 ±0·021) and by Martin and Mason (*10*) who also worked with Upland cottons (r 0·56 ±0·016). Patel (*11*) in three strains of *Gossypium herbaceum* in India obtained coefficients of from 0·46 ± 0·05 to 0·73 ±0·03.

Mean weight of individual seeds with fibre length. This correlation was not determined in Arizona, but Hodson (*4*) reports for five populations of Upland cottons coefficients ranging from —0·04 ±0·11 to 0·30 ±0·066 and 0·33 ±0·10. Dunlavy (*2*), also working with Upland cottons, got a coefficient of 0·426 ±0·043.

Mean weight of individual seeds with percentage 5-lock bolls per plant. Dunlavy (*2*) found no significant correlation in Upland cotton (r 0·114 ±0·055).

Mean weight of individual seeds with boll length. No correlation was shown by 224 individual bolls of Pima cotton in 1925 (r 0·059 ±0·045).

Mean weight of individual seeds with boll diameter. A low but apparently significant positive correlation was shown by 224 individual bolls of Pima cotton in 1925 (r 0·189 ±0·043).

Mean weight of individual seeds with boll index. No correlation was shown by 224 individual bolls of Pima cotton in 1925 (r 0·076 ±0·045).

The correlations of the mean weight of individual seeds with seed cotton weight per boll, fibre weight per boll, and number of seeds per boll have been mentioned under those characters as subjects.

Lint percentage with lint index. A fairly high and very significant positive correlation was shown in 1925 by 224 individual bolls of Pima cotton (r 0·540 ±0·032). Closer correlation was shown (*5*) in two populations of Egyptian cotton grown in Arizona in 1910 (r 0·64 ±0·045 and 0·83 ±0·034) and in a population of Pima cotton in 1924 (r 0·868 ±0·023). Martin and Mason (*10*) obtained a coefficient of 0·42 ±0·02 and Dunlavy (*2*) the exceptionally low coefficient of 0·203 ±0·050.

Lint percentage with fibre length. The correlation of these characters was not determined on Arizona material. Other investigators report coefficients for Upland cotton as follows: Hodson (*4*) in five populations obtained coefficients ranging from —0·034 to —0·311, three of which (all negative) may have been significant; Dunlavy (*2*) —0·445 ±0·042; Martin and Mason

(*10*) —0·21±0·023 ; and Stroman (*12*) significant correlations in only 4 out of 16 varieties, all negative, with coefficients ranging from —0·37±0·09 to —0·52±0·07. Negative correlation between lint percentage and fibre length in Upland cotton is strongly indicated by these data. Kottur reports these characters to be independent in the Indian cottons with which he worked (*9, p. 129—133*).

Lint percentage with percentage 5-lock bolls per plant. Dunlavy (*2*) found no significant correlation in Upland cotton (*r* 0·036±0·056).

Lint percentage with boll length. A low but apparently significant positive correlation was shown by 224 individual bolls of Pima cotton in 1925 (*r* 0·179 0·044).

Lint percentage with boll diameter. No correlation was shown by 224 individual bolls of Pima cotton in 1925 (*r* 0·074±0·045).

Lint percentage with boll index. A low but possibly significant negative correlation was shown by 224 individual bolls of Pima cotton in 1925 (*r*—0·142±0·044). It has been shown, however, that this apparent correlation probably is due to the high negative correlation of boll length with boll index.

The correlations of lint percentage with seed cotton weight per boll, fibre weight per boll, seed weight per boll, number of seeds per boll, and mean weight of individual seeds have been mentioned under those characters as subjects.

Lint index with fibre length. This correlation was determined in Arizona on seven populations of Egyptian cotton, of which six were of the Pima variety. In only three populations (all of Pima cotton) the coefficients were apparently significant, having been 0·360±0·055, —0·132±0·038 and —0·361±0·085. Since one of the apparently significant coefficients was positive and the other two negative, no general conclusion in regard to this correlation is possible. For 180 F_2 plants of an Upland Egyptian hybrid grown at Sacaton in 1919 the coefficient of correlation was —0·098±0·050. Dunlavy (*2*) reports a coefficient of correlation between fibre length and lint index of 0·153±0·051, while Martin and Mason (*10*) obtained a coefficient of only 0·07±0·024.

Lint index with fibre color. No correlation was shown by 180 F_2 plants of an Upland Egyptian hybrid at Sacaton in 1919 (*r* 0·033±0·050).

Lint index with seed fuzziness. No correlation was shown by 180 F_2 plants of an Upland-Egyptian hybrid in 1919 (*r* 0·090±0·050), by 178 individual selections of Pima cotton in 1922 (*r* —0·061±0·050), and by 224 individual bolls of Pima cotton in 1925 (*r* 0·042±0·045). A coefficient of —0·327±0·100 was obtained on 36 individual selections of Sakellaridis cotton at Sacaton in 1922, but the population was too small to make it likely that this correlation is significant.

Lint index with percentage 5-lock bolls per plant. Dunlavy (2) found no significant correlation in Upland cotton (*r* 0·078±0·056). In the second generation population of an Upland-Egyptian hybrid grown at Sacaton in 1919 (180 plants) there was no correlation between lint index and mean lock number per plant (*r* 0·014±0·050).

Lint index with boll length. A low but significant positive correlation was shown by 224 individual bolls of Pima cotton in 1925 (*r* 0·237±0·042).

Lint index with boll diameter. A low but significant positive correlation was shown by 224 individual bolls of Pima cotton in 1925 (*r* 0·228±0·042).

Lint index with boll index. No significant correlation was shown by 224 individual bolls of Pima cotton in 1925 (*r*—0·100±0·045).

The correlations of lint index with seed cotton weight per boll, fibre weight per boll, number of seeds per boll, mean weight of individual seeds, and lint percentage have been mentioned under those characters as subjects.

Fibre length with fibre color. For 180 F_2 plants of an Upland-Egyptian hybrid grown in Arizona in 1919 the coefficient of correlation was —0·230±0·048 indicating a slight but probably

significant tendency for the plants with longer fibre to have lighter colored fibre. Kottur (*9, p. 124—129*) noted a tendency in Indian cottons for shortness of staple to be associated with brown color of the fibre, but he did not determine the coefficient of correlation.

Fibre length with seed fuzziness. No significant correlation was shown in Arizona by three populations, one of the Pima variety (r 0·046±0·051) one of the Sakellaridis variety (r 0·283±0·103), and one of the second generation of an Upland-Egyptian hybrid (r 0·050±0·050).

Fibre length with percentage 5-lock bolls per plant. Dunlavy (*2*) found no significant correlation in Upland cotton (r —0·109±0·055). In the second generation of an Upland-Egyptian hybrid at Sacaton in 1919 (180 plants) fibre length and boll lock number (mean per plant) were not significantly correlated (r —0·127±0·049).

The correlations of fibre length with seed cotton weight per boll, mean weight of individual seeds, lint percentage, and lint index have been mentioned under those characters as subjects.

Fibre color with seed fuzziness. For 180 plants of Upland-Egyptian F_2 in Arizona in 1919 the coefficient of correlation was negligible (r —0·016±0·050).

The correlations of fibre color with lint index and fibre length have been mentioned under those characters as subjects.

The correlations of seed fuzziness with lint index, fibre length and fibre color have been mentioned under those characters as subjects.

Boll length with boll diameter. A fairly high and very significant positive correlation was shown by 224 individual bolls of Pima cotton in 1925 (r 0·385±0·038). This correlation was determined in Arizona also on seven other populations of Pima and other varieties of Egyptian cotton. The coefficients ranged from 0·21 to 0·73 (0·5 or higher in six cases), and were significant in all but one case. For 180 F_2 plants (one boll per plant) of an Upland-Egyptian hybrid at Sacaton in 1919 the coefficient of correlation was 0·289±0·046.

Boll length with boll index. The expected high and very significant negative correlation was shown by 224 individual bolls of Pima cotton in 1925 (r —0·680±0·023). As determined in Arizona on seven other populations representing several Egyptian varieties, the coefficients of correlation ranged from —0·59±0·07 to —0·795±0·028. For 180 F_2 plants of an Upland-Egyptian hybrid grown in 1919 the coefficient was —0·703±0·025.

*Boll length with boll apex index,** For 180 F_2 plants of an Upland Egyptian hybrid grown at Sacaton in 1919 the coefficient of correlation was —0·504±0·038.

Boll length with boll volume. The correlation with volume of the fully developed but unopen boll (as measured by the displacement of water) was determined in 1916 on three lots of bolls, each boll having been from a different individual plant. For 161 bolls of the Pima variety the coefficient was 0·64±0·031; for 207 bolls of the Gila variety, 0·73±0·022; and for 407 bolls of Pima×Gila F_2, 0·62±0·021. The length of the boll therefore gives a good indication of its volume.

The correlations of boll length with seed cotton weight per boll, fibre weight per boll, number of seeds per boll, mean weight of individual seeds, lint percentage and lint index are mentioned under those characters as subjects.

Boll diameter with boll index. A significant positive correlation was shown by 224 individual bolls of Pima cotton in 1925 (r 0·325±0·040). Of seven other populations of Egyptian cotton in Arizona only three gave significant coefficients (r 0·116±0·032, 0·23±0·05, and 0·467 ±0·069). The coefficient for 180 F_2 plants of an Upland-Egyptian hybrid was 0·376±0·043.

Boll diameter with boll apex index. For 180 F_2 plants of an Upland-Egyptian hybrid grown at Sacaton in 1919 the coefficient of correlation was —0·079±0·050.

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* The boll apex index is the diameter 5 mm. below the apex taken as a percentage of the maximum diameter. Round bolls have a high, and pointed bolls a low, index.

Boll diameter with boll volume. This correlation was determined on the same populations as was the correlation of boll length with boll volume, and the coefficients obtained were: Pima, 0·73±0·025; Gila, 0·82±0·015; and Pima Gila F_2, 0·79±0·012. The volume of the boll therefore was even better indicated by the maximum external diameter than by the length. It is possible also that diameter is more closely correlated than length with the weight of seed cotton and of fibre per boll. (Table I).

The correlations of boll diameter with seed-cotton weight per boll, fibre weight per boll. number of seeds per boll, mean weight of individual seeds, lint percentage, lint index, and boll length are mentioned under those characters as subjects.

Boll index with boll apex index. For 180 F_2 plants of an Upland Egyptian hybrid grown at Sacaton in 1919 the correlation was significant and positive (r 0·448±0·040), as would be expected since relatively slender bolls usually have pointed tips and *vice versa*.

The correlation of boll index with other characters are mentioned under those characters as subjects.

The correlations of boll apex index with boll length, boll diameter and boll index are mentioned under those characters as subjects.

The correlations of boll volume with boll length and boll diameter are mentioned under those characters as subjects.

EVIDENCE OF GENETIC CORRELATION.

All of the correlations discussed in this paper which gave high coefficients are more or less obviously physical or physiological. The populations on which the correlations were determined were not of a nature to afford evidence as to the occurrence of genetic correlation, except in the case of 180 F_2 plants of an Upland-Egyptian hybrid, grown in 1919 (8). In this population the coefficients of correlation were computed for all possible combinations of the following characters :—

1. Lint index.
2. Fibre length.
3. Fibre color.
4. Seed fuzziness.
5. Boll lock number.
6. Boll length.
7. Boll diameter.
8. Boll index.
9. Boll apex index.

The first four characters were determined as the average for five mature bolls from each plant and the last four characters on a single, fully developed but unopen boll on each plant. The mean boll-lock number for each plant was computed by counting the number of locks in every boll on the plant. The coefficients of correlation were computed by the product-moment method, none of the characters having shown segregation in definite ratios.*

Ten of the 36 pairs of characters gave coefficients of correlation amounting to three or more times the probable error. These coefficients are given in Table V.

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* The seed coat character (seed fuzziness) in crosses between cottons which have, respectively, naked and fuzzy seeds, shows definite monohybrid segregation, absence of fuzz being dominant. But such segregation was not observed in the Upland-Egyptian hybrid under consideration, both parents of the hybrid having had more or less fuzzy seeds.

Table V.

Significant correlations among seed, fibre and boll characters of an Upland × Egyptian F_2 population (180 plants).

Character pair	Coefficient of correlation (r)	r/E	Character pair	Coefficient of correlation (r)	r/E
Lint index . . . / Boll diameter . .	0·214 ± 0·048	4·5	Boll length . . / Boll diameter . .	0·289 ± 0·046	6·3
Fibre length . . / Boll length . .	·175 ± ·049	3·6	Boll length . . / Boll index. . .	—·703 ± ·025	28·1
Fibre length . . / Boll apex index . .	— ·172 ± ·049	3·5	Boll length . . / Boll apex index .	— ·504 ± ·038	13·3
Fibre length . . / Fibre color . .	— ·230 ± ·048	4·8	Boll diameter . . / Boll index. . .	·376 ± ·043	8·7
Boll lock number . / Boll diameter . .	·202 ± ·048	4·2	Boll index. . . / Boll apex index .	·448 ± ·040	11·2

All but the first four correlations in Table V may be dismissed as obviously or probably of a physical or physiological nature. That this applies to the inter-correlations of boll length, boll diameter and boll index (diameter as a percentage of the length) has been brought out in preceding pages. The positive correlation between boll lock number and boll diameter is obviously physical. A much closer correlation doubtless would be shown by determinations on the same individual bolls. The negative correlation between boll length and boll apex index (diameter 5 mm. below the apex as a percentage of the maximum diameter) is probably a physiological one, since the most cursory observation of a series of cotton varieties shows that long bolls tend to be pointed, and *vice versa*. A similar relation is expressed in the positive correlation of boll index with boll apex index which indicates that slender bolls (having a low boll index) tend to be pointed and *vice versa*.

The positive correlation of lint index with boll diameter, although coherent (in the direction indicated by the parental associations of the characters) is in all probability a physiological one, since the 224 individual bolls of Pima cotton in 1925 gave very nearly the same coefficient (r 0·228 ± 0·042). The correlation probably expresses merely a like influence of environmental conditions upon two otherwise independent characters.

The low positive correlation of fibre length with boll length and the low negative correlation of fibre length with boll apex index probably indicate a slight physiological tendency for the longer and more pointed bolls to contain longer fibre. A comparison of different types and varieties of cotton shows that the long-staple varieties mostly have long and pointed bolls. Both correlations are coherent, however, and the evidence at hand does not exclude the possibility that a weak linkage is involved. Closer correlation might have been shown if the fibre character and the boll characters had been determined on the same individual bolls. The correlations of the two boll characters with fibre length evidently are not independent, being connected by the rather high negative correlation between boll length and boll apex index (r —0·504 ± 0·038). This is shown by the partial correlations, that of fibre length with boll length *constant* for boll apex index giving a coefficient of only 0·103 ± 0·050 and that of fibre length with boll apex index *constant* for boll length giving a coefficient of only 0·098 ± 0·050.

The only one of these ten correlations in which physical or physiological association of the characters seems improbable is the negative correlation between fibre length and fibre color, the coefficient (r —0·230 ± 0·048) being nearly five times its probable error. This correlation is, however, disherent, the Upland parent having had shorter and lighter colored fibre than the Egyptian parent, whereas the hybrid shows a tendency for longer fibre to be associated with lighter colored fibre and *vice versa*. Such a correlation, if it is really genetic, may be interpreted only on the unproven assumption that crossing over in excess of 50 per cent. has occurred. An association of short staple with brown color in Indian cottons was noticed by Kottur (*9, p. 124—129*), but he did not determine the coefficient of correlation.

The only case in which linkage of any of the characters of the cotton plant discussed in this paper appears to have been demonstrated is that between sparse lint (low lint index) and naked seeds, reported by Thadani (*13*).

Summary.

The intercorrelations of various characters of the bolls, seeds and fibre have been determined in Arizona on several populations of cottons of the Egyptian type, and on a population of 180 second generation plants of a hybrid between Upland and Egyptian cotton.

The coefficients of correlation were computed on 224 (or 250) individual bolls borne by 50 plants of Pima Egyptian cotton at Sacaton, Ariz., on 1925, for all possible combinations of the characters seed-cotton weight per boll, fibre weight per boll, lint percentage, lint index, number of seeds per boll, mean weight of the individual seeds, boll length, boll diameter and boll index, a total of 36 pairs of characters. The coefficients of correlation are given in Table I. For 26 pairs of characters the coefficients are probably significant, being more than three times the probable error.

There were also computed in 1925 coefficients of correlation for eight pairs of characters on 25 samples from as many fields in the Salt River Valley, Ariz., each sample having consisted of 100 bolls. A comparison of these coefficients with the coefficients obtained for the same pairs of characters on the 224 individual bolls is made in Tables III and IV. For three of the eight pairs of characters the coefficients differ markedly, although the significance of the differences is doubtful. This comparison shows clearly, however, the danger of generalizing as to the correlation of characters on the basis of a coefficient determined on a single population and under one set of environmental conditions.

These and all other correlations determined in Arizona, together with references to the published data of other investigators who worked chiefly with Upland cottons, are brought together in a synopsis. The subjects of the correlations are arranged so as to facilitate reference.

Evidence as to the occurrence of linkage, afforded by the correlations of characters in a second-generation population of an Upland-Egyptian hybrid, is discussed in the concluding section. Coefficients higher than 0·25 were obtained in the hybrid only in cases where the correlation is obviously or very probably of a physical or physiological nature, in other words due to the mathematical relationship of the characters or to a like effect of environmental conditions upon otherwise independent characters.

Among the characters considered in this paper, the only significant correlation found by the writer which appears to be neither physical nor physiological is the negative correlation between fibre length and fibre color in the Upland-Egyptian hybrid, which gave a coefficient of $-0{\cdot}230 \pm 0{\cdot}048$. In this case the correlation is disherent, since in the parents of the hybrid long fibre was associated with deeper colored fibre, and *vice versa*. Linkage in this case would have been indicated by a positive correlation unless crossing over in excess of 50 per cent. is assumed to have taken place.

An apparently well-substantiated case of linkage between sparseness of the fibre and absence of fuzz on the seeds and *vice versa*, has been reported by Thadani (*13*).

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NOTES

EFFECT OF ROTATIONS ON COTTON PRODUCTION.

BULLETIN No. 365 of the Texas Agricultural Experiment Station (Division of Agronomy) entitled "Crop Rotation in the Blackland Region of Central Texas" contains some interesting results on the effect of rotations on cotton production in that State. The authors, Messrs. E. B. Reynolds and D. T. Killough, state that the Blackland region of Central Texas has been noted for the productiveness or fertility of its soils, as shown by the large, consistent and dependable yields of cotton. When these soils were first put into cultivation, it was commonly believed they would not wear out, that they were practically inexhaustible. The almost continuous culture of cotton on these black waxy soils for the last fifty years without proper effort either to maintain or to increase the productiveness has led to a noticeable decrease in yield. Records are at hand which show that these soils are not as productive now as they were when first put into cultivation. The figures quoted show that the average production of cotton per acre has fallen from 226 lb. for 1866-75 to 135 lb. for 1916-25 for Texas State as a whole. For the Blackland region the seven-year smoothed average since 1902 has fallen from 215 lb. to 151 lb., a similar smoothed average for the whole State being 173 lb. falling to 135 lb. It will thus be seen that the decreases are more marked in the Blackland region and so cannot be entirely attributed to the boll-weevil. The authors show also that these black waxy soils have not permanently lost their productiveness which can be restored by the use of proper methods of management, and further that a considerable part of the progressive decrease in yield, when cotton is grown year after year, is due to the increased incidence of root-rot which was found to be as high as 33 per cent. (eight-year average) with continuous cotton growing as compared to 6-7 per cent. with rotations. With a four-year rotation which included maize, wheat and leguminous crops, the increase of cotton yield per acre was over 100 per cent. and in the three-year rotations the increase was over 50 per cent. in the least favourable and 94 per cent. in the most favourable. [B. C. BURT.]

ARTIFICIAL INFECTION OF PENNISETUM TYPHOIDEUM BY SCLEROSPORA GRAMINICOLA.

AMONG the cultivated crops in the Bombay Presidency, *Pennisetum typhoideum*, locally known as *bajri*, occupies a very prominent place. An important disease attacking this crop is the downy mildew caused by *Sclerospora graminicola*. Al-

though the disease has been known for a long time, it has not definitely been determined as to how it lives from year to year and causes infection of the young *bajri* plants. It is generally believed that this fungus hibernates by means of oospores, but it has not been possible to germinate them artificially and cause infection of *bajri*. This led the writers to try infection of this host with the oospores of *Sclerospora graminicola*.

Bajri seeds were sown in sterilized soil, and oospores were placed either on the seed or in the soil. This soil was copiously watered and covered with a bell-jar. The pots containing this soil were then kept standing in a basin of water.

After the emergence of the seedlings from the soil, the visible symptoms appear first on the third leaf, the first and the second leaves being apparently healthy. In many cases 60 per cent. of the plants exposed became infected.

The infected leaves were placed on a dry slide in a petri-dish lined inside with wet blotting-paper. The petri-dish was wrapped with a wet cloth and a continuous stream of water at 15° to 20° C. was made to run on it. The atmosphere within the petri-dish was so completely saturated that the leaves were covered with a film of moisture. Under these conditions, sporulation occurs within 5—6 hours. The optimum temperature for sporulation is 15° to 17° C. The sporangia readily germinate in water at these temperatures and produce zoospores. [B. N. Uppal and M. N. Kamat.]

SCUM ON THE WATER SURFACE OF RICE FIELDS.

Much damage is caused to the rice crop in North Sind by the formation of a thick layer of algæ upon the water surface, if for any reason the water remains stagnant, as for example, where there is no natural fall in the level from field to field or again in low-lying places. It is comparatively rarely found where the water circulates freely from the higher field to the lower. Rain is also a preventive. This scum begins to develop soon after transplantation and in bad cases it increases until there is a thick green carpet resting upon the water surface, pierced only by the rice clumps. Gradually this scum tightens its grip round these clumps which become partially strangled and tillering is prevented. The condition of the crop suffers considerably from lack of aeration and because the plants are not free to thicken and spread. This trouble recurs in certain fields each year, gradually becoming more intense.

The following treatment worked out on the Larkana Experimental Station has given excellent results. About 16 to 20 lb. (worth Rs. 12-8-0) of copper sulphate crystals per acre should be put in a cloth bag which is drawn through the plot under the water surface so as to ensure uniform distribution.

Less quantities of copper sulphate will do if only a part of the field is covered by scum.

PLATE XXVI.

A plot of Prong rice infested with scum.

The same plot of Prong rice ten days after treatment with copper sulphate.

The scum dries up and settles leaving a clear water surface three to five days after the application of the treatment and *does not* reappear with subsequent irrigations.

A badly affected plot is shown in Plate XXVI before and after treatment. In this case the crop was observed to have started fresh growth ten days after the application of the treatment. [DURGA DUTT H. VASISTHA.]

THE PUSA SCIENTIFIC ASSOCIATION.

WE have received the following for publication :—

The Pusa Scientific Association, which affords a meeting ground to the staff of the Institute for the discussion of problems bearing on agriculture and its allied sciences, held seven ordinary meetings during 1927.

On 17th March, 1927, Mr. S. C. Roy read a paper on *The Improvement of the Human Race*, in which he dealt briefly with the various aspects of the modern science of eugenics and discussed the main problems connected with race improvement. He said that the first link in the chain of evidence was forged long ago by Darwin who showed that man had already risen in the past from a simple and lower type of animal, while Galton showed that modern man was capable of vast improvements —a line of thought which was later taken up by a number of distinguished workers like Pearson and others. "An individual," he declared, "has two fundamental things which mould his future character—(1) nature, *i.e.*, his hereditary endowments and (2) nurture, *i.e.*, his environments. Nature has a far greater influence over him than nurture." The meeting was presided over by Dr. Shaw.

At the next meeting held on 2nd April, Mr. G. I. Kavoor read a paper on *The Application of Science in Modern Agriculture*, Dr. D. Clouston presiding. It was pointed out that agriculture depended upon the fundamental sciences amongst which botany and chemistry had the closest relation to it. The application of botany in farming was three-fold, *viz.*, plant-breeding, plant pathology and plant physiology. In India Howard's Pusa 4 and 12 wheats and Barbar's Co. 213 cane were triumphs of plant-breeding, while Dr. Butler's work on plant diseases was of great value to the agriculturist. Chemistry was instrumental in revealing the elements on which depended the agricultural values of land, and thus helped in providing a proper medium for the plant to grow in. Animal breeding, veterinary science and entomology were branches of applied zoology. Stock breeding was now a business enterprise and the breeder was turning more and more to science for help in his many varied problems. Geology by its survey of rocks and minerals had helped the agriculturist to understand the soil and its peculiarities. Economics showed the overriding influence of the economic factors in all matters affecting the management and development of land, while

statistics showed the farmer how to predict his yields and other important items even after a few field trials. Mechanical engineering had brought about the introduction of modern agricultural implements, and a careful and scientific control of water by improved methods of irrigation and drainage brought about better yields.

Under the presidency of Dr. D. Clouston, Mr. G. Gosling, a representative of Messrs. Adair, Dutt & Co., gave a short discourse on *Scientific Kinematography* on 30th April, and screened a few films taken by him with the help of a small, handy camera regarding the working of which he gave necessary details.

In the fourth meeting held on 16th June, under the presidency of Mr. P. V. Isaac, Mr. M. Mitra read a paper on *The Andamans and its People*. A short account was given of the island and its people, the area under occupation and that under cultivation, the more important fauna and flora of the place, the chief timbers found, and the manners and customs of the Andamanese and of the various other tribes, their relationship with the Government and other important details about them. Several photographs, charts and ornamental shells brought from the island were also shown round.

Mr. P. V. Issac also presided over the fifth meeting held on 22nd August when Mr. K. K. Guha Roy read a paper on *Library Classification and Cataloguing*. A comparative study was made of all the standard methods of classification, and it was suggested that the system worked out by Mr. Brown of the Library Association of England was the best adaptable to a departmental library with such modifications as were necessitated by local conditions. A system of classification suitable for an agricultural library was also demonstrated. Catalogueing could be divided into four classes :- (1) Authors, subjects and titles in one alphabet ; (2) Arranged according to authors ; (3) Subjects arranged systematically according to their relationship, and (4) Subjects arranged alphabetically. The most serviceable catalogue, however, was said to be that formed by classes (2) and (4), that is, an author catalogue and a subject catalogue, each arranged in a separate alphabet.

Rao Saheb Kasanji D. Naik read a paper on the *Sugar Factories in India* on 28th September when Mr. N. V. Joshi presided. It was shown that the total number of sugar factories and refineries working in India was 39 of which 26 dealt direct with cane while the remaining 13 refined *gur*. This number was very small when compared with 178 in Java and 177 in Cuba. The total output of sugar from all Indian factories dealing with cane amounted to 62,900 tons in 1926-27 which was less than the production of a single large factory in Cuba. The initial capital cost of a factory in India compared unfavourably with the proportionate cost of a large factory in other countries and most concerns here suffered from under-capitalization. Until recently efficient milling plants capable of effectively crushing the thin, hard and fibrous canes grown in Northern India were hardly used and the result was low-extraction. It was suggested that factories which do not usually grow their own cane ought to take more interest in the growers who supply them

with the cane. By the distribution of improved seed canes, oil-cakes and other fertilizers to the growers they would be rendering a good service to themselves as well as to the growers. The development of the sugar industry, according to Rao Saheb, was beneficial to India from all points of view. A sugar factory, unlike a cotton mill, is usually located in the heart of the cane-growing district, and therefore provides employment in rural districts. As India imports sugar from abroad, the development of the white sugar industry would enrich the country and so deserves to expand.

The last meeting of the year was held on 28th November when Mr. S. L. Das read a paper on *Some Problems in Agriculture*, Dr. D. Clouston presiding. The paper dealt at length on the main problems of agriculture, the effects of manures, soils, climatic changes and different plant pests on crops and showed how the environmental and soil factors could be controlled. The need of fuller co-operation between men visualizing the problems from different points of view and between agricultural institutions existing in various parts of the world by opening a chain of research stations was advocated. "Our declared aim," according to the lecturer, "should always be to discover the principles underlying the great problems of agriculture and to put the knowledge thus gained into a form in which it could be used by teachers, experts and farmers for the upraising of country life and the improvement of the standard of farming."

CHEMOTROPISM IN THE COTTON PLANT.

It has been known for some time that the moist layer on the under surface of the leaves, and on the buds and young shoots of the cotton plant, is markedly alkaline in reaction (pH. 8·5, or thereabouts), whereas the tissue fluid, as is the case with the great majority of plants, is acidic (pH. 5·2 to 5·5). This implies that some sort of alkaline substance is exuded by the plant and dissolves in the dew. (See C. M. Smith, *J. Ag. Res.*, 1923, 26, p. 192; J. E. Mills, *Science*, Sep. 19, 1924, p. 268, and Harris, Hoffman and Johnson, *ibid*, Jan., 16, 1925, p. 65). These observations have suggested that a soluble volatile base, probably belonging to the alkyl amines, is produced and liberated by the cotton plant, and, further, that this substance may be, at least in part, responsible for the specific attraction which the cotton plant exerts towards certain of its insect pests, in particular, the cotton boll weevil, which annually demands high toll in the cotton fields of America.

The importance of these facts and suggestions do not need stressing. Obviously, if the exact identity of the chemotropic substance of the cotton plant could be established, the substance may be synthesised or otherwise obtained in sufficient quantity to permit its use as a bait for trapping those insect pests of the cotton

plant that react specifically to its influence. Hence great economic significance attaches itself to any attempts to identify the odorous volatile component of the cotton plant.

Perhaps the first attempt to isolate the volatile component was made in 1918 by Viehoever, Chernoff and Johns *J. Ag. Res.*, 1918, 13, p. 345. The material used consisted chiefly of cotton seedlings grown at Tallulah, Louisiana, U. S. A. About 1820 kg. of fresh plant material were distilled, and from the distillate, some 29 g. of a brown essential oil were extracted by the use of ether. The oil was found to contain no furfural, and the higher boiling fractions were observed to possess a blue colour ; otherwise, none of its characters nor components was further determined.

Recently, another and more elaborate effort has been made to isolate and to identify the odorous component of the cotton plant by F. B. Power and V. K. Chestnut at the Phytochemical Laboratory of the Bureau of Chemistry of the United States Department of Agriculture. This work was undertaken at the request of Dr. L. O. Howard, Chief of the United States Bureau of Entomology, and its results are fully described in the *Journal of the American Chemical Society*, June, 1925, 47, 6, p. 1751, from which the following summary is abstracted.

A ten-acre field of Upland cotton at Tallulah was set aside for the investigation. The plants were 60 to 200 cm. high at the time of reaping, during July and August, 1923. Only foliage, squares, flowers and small bolls were distilled, and their combined mass amounted to some 3,290 kg. The distillate (5,300 litres) was a slightly turbid liquid containing some globules of colourless oil floating on the surface. It possessed a characteristic persistent and rather pleasant odour, although the first portions were somewhat pungent. Part of the distillate, after concentration by cohobation, was extracted with ether. The essential oil thus isolated represented approximately 0·0031 per cent. of the mass of original green material. It was a pale, yellowish, limpid liquid, which darkened in colour on exposure to air. Its odour was agreeable and persistent. An aldehyde and furfural were definitely identified in it.

The concentrated distillate, which represented all the odorous and volatile components of the young cotton plants, was found to contain the following substances :—(1) Methyl alcohol in large amount, and traces of actone ; (2) amyl alcohol and certain of its higher homologues, in small quantity ; (3) acetaldehyde, and traces of a higher aldelyde ; (4) vanillin, in small amount ; (5) a trace of a phenol ; (6) an optically inactive dicyclic sesquiterpene ; (7) a new optically active tricyclic sesquiterpene ; (8) a paraffin hydrocarbon (probably triacontane) ; (9) a blue oil, probably containing the highly unsaturated hydrocarbon, azulene ; (10) formic, acetic and caproic acids, possibly in combination as esters with previously mentioned alcohols ; (11) ammonia ; (12) trimethylamine. The two last were present in considerable amounts in the distillate, ammonia predominating. Doubtless, these are the soluble bases which confer a marked alkaline reaction on the dew that

collects on the plant surface, as was mentioned at the outset. Both ammonia and trimethylamine were also found to comprise the emanations that come from the living cotton plant. Trimethylamine has been proved by field tests to possess some attraction for the cotton boll weevil, but further experiments have yet to be undertaken in order to determine definitely whether or no it can be employed as an artificial bait.

It may be noted that the emanation of ammonia and trimethylamine from the cotton plant is probably due to the well-known interaction between fixed alkali carbonate and an ammonium salt and choline respectively. The alkali may be secreted in special glanular hairs that cover the under epidermis of the leaves. The ammonium salts and choline doubtless occur in the tissue fluids, and may be exuded at the leaf surface, where they come into contact with the alkali. Choline has definitely been identified in the cotton seed, and is very widely distributed in plants, since it is a constituent of the phosphatide, lecithin, which is a component of all living cells. (Onslow, Pract. Plant Biochemistry, 1923, p. 171). Numerous plants, other than cotton, spontaneously evolve ammonia and trimethylamine. Thus certain species of Chenopodium are characterised by this property, and in consequence, possess a very strong fetid odour, due to trimethylamine chiefly. Alkali carbonates, furthermore, have been identified in greater or lesser quantity in the liquid secretions of many plants, for example, the scarlet runner bean (*Phaselous multiflorus*), Ochra (*Hibiscus esculentus*), and other members of the family Malvaceae, including cotton.

Finally, Clifford and Fargher (*J. Textile Inst.*, 1923, 14, p. 117) have isolated both ammonia and trimethylamine from cotton fibre by distillation with caustic soda under pressure, this result further suggesting that ammonium salts and choline occur in the content of cotton bolls, as well as in the superficial tissues of the bolls and in the tissues of other green parts of the plant. [Prof. F. HARDY in *Tropical Agriculture*, Vol. IV, No. 6.]

COTTON NOTES.

THROUGH the courtsey of the British Cotton Industry Research Association, the Secretary, Indian Central Cotton Committee, has sent the following abstracts for publication :-

ROTTING OF COTTON BOLL.

Two forms of decay of cotton bolls, frequently referred to as "smut" in their later stages, occur commonly in the south-western United States. These diseases are not true smuts and have only a superficial resemblance to smuts. One is caused by *Aspergillus niger* and the other by *Rhizopus nigricans*. The two diseases may

be readily distinguished by the discoloration of the affected tissues as well as by the character of the fruiting stages of the parasites. Both organisms readily produced rot in artificially wounded and inoculated cotton bolls, but failed to affect uninjured bolls. Infection in the field apparently depends on injuries caused by various insects, the most noticeable of which are those caused by the bollworm, and control measures will have to be directed chiefly against these insect pests. [*Jour. Agri. Res.*, 1927, 35, 307-312. MICHAEL SHAPOVALOV.]

EFECT OF ACIDITY ON MILDEW FUNGI.

A series of culture media, with pH varying from 2·8-9·0 were impregnated with various fungi. Graphs show that for speed of growth the optima concentrations lie between pH=3·8 to 8·6. Organisms with the most primitive reproduction apparatus grow best in nearly neutral media. The more pronounced the differentiation in reproduction, the more closely optimum speed of growth follows acidity. There is here some connection between reproduction and the H-ion concentration of the medium. [*Int. Rev. Sci. Pract. Agri.*, 1927, *18*, T395-396; from *Bull. Sci. pharmacol.*, 1927, *34*, 75-79. A. SARTORY, R. SARTORY and J. MEYER.]

SOIL TEMPERATURES IN EGYPT.

During the periods of germination and increase in height of the cotton plant, the soil temperatures are rising and the amplitude of the temperate wave is at its maximum. The maximum soil temperatures decline while the minimum soil temperatures remain constant, thus resulting in a gradual decrease in the amplitude of the daily temperature wave during the branching and flowering periods. Throughout the soil zone occupied by the roots of the plant, the temperature is the same, the amplitude of the daily temperature wave small, and the temperature is constant during the boll development and maturation periods. The main effect of irrigation on soil temperatures is to reduce the amplitude of the daily temperature wave, no sudden change of temperature in the root zone taking place. From a consideration of the range of air temperature in other cotton producing countries, it seems probable that the characteristics of the soil temperatures during the boll development and maturation periods are the same for all countries. [*Jour. Agri. Sci.*, 1927, *17*, 489-501. E. MCKENZIE TAYLOR.]

SALT INTAKE OF COTTON SEEDLING.

Results of experiments are tabulated showing the absorption and growth of Egyptian and Upland types of cotton seedlings from solutions containing chloride or sulphate. In the sulphate series the Egyptian type absorbed more of the sulphate than the Upland type. In the chloride series the Egyptian type generally absorbed

more than the Upland type but results were not so consistent at low concentrations of chloride. The results suggest that the absorption of chloride and sulphate by the roots of plants may not bear the same relationship to one another in the different types of cotton seedlings as do the chloride and sulphate content of the leaf tissue fluids, and therefore, the absorption of ions as a basis for distinctions between different types of cotton seedlings requires further study. [*Bot. Gaz.*, 1927, *84*, 324-327. A. R. C. HAAS.]

CONTROL OF COTTON INSECT PESTS IN NIGERIA.

An outline of the entomological work done on cotton pests in recent years by members of the Nigerian Agricultural Department. The cotton stainers, *Dysdercus* spp., are the most important pests in Nigeria and the Ilorin Province. Biological methods of control are not effective and close season measures and use of poisons are impracticable. Selective breeding has produced strains of Ishan (*vitifolium*) superior to Allen (*hirsutum*) which is less subject to stainers and which would probably be comparatively immune when grown according to native custom, *i.e.*, in small areas and intercropped. [*Proc. First W. African Agri. Conf.*, 1927, pp. 129-145. F. D. GOLDING and O. B. LEAN.]

COTTON INSECT PEST IN ARIZONA.

The tarnished bug, *Lygus elisus*, Van Dazee, is perhaps the most serious pest of cotton on the Pacific coast. Injury is caused by feeding punctures made in the squares, blooms and bolls which are then soon shed. It is supposed that either a toxic material or an organism is introduced into the plant tissue. The pest produces characteristic yellow daubs. Infested alfalfa, growing in the neighbourhood, is a common source of acute attacks on cotton. Finely-divided sulphur dust has been found effective against the tarnished bug. [*U. S. Dept. Agri. Technical Bulletin No. 4.* E. A. MCGREGOR.]

COTTON CULTIVATION IN U. S. A. (TEXAS).

A study of yield figures for the years 1879-1926 seems to show that the average yield of cotton per acre in Texas has declined since about 1894, compared with that of the United States as a whole. A general cause applicable to the whole State is the boll weevil. An analysis of the census figures for 1924 shows that the yield in the North-East and East, and also in the West, is very unsatisfactory, whilst in Central Texas and the South the average result is also too low. The following possible causes are indicated: Frequent droughty years alternating with years of excessive rainfall in harvest season; pursuing cultivation too far west where rainfall is normally insufficient; exhaustion of soil due to continuous cultivation of cotton and non-use of fertilisers; and insect pests and plant diseases.

The increasing production of half-and-half and other short-stapled varieties, and the growing proportion of snaps, bollies, and sledded cotton are lowering the general character of Texas cotton. [*Int. Cotton Bull.*, 1928, *6*, 268-269. J. A. TODD.]

The results of the Texas cotton-growing contest which, to date, has been entered by more than 15,000 farmers each of whom farmed 5 acres of cotton intensively to determine the best methods of producing the maximum yield, seem to indicate that profit lies in the intensive farming of a smaller acreage. Much of the black lands of North, Central and South Texas should be rotated as they show decided cotton sickness. Much suffers from cotton root rot fungus, the spread of which would be arrested by planting small grains, sorghum or corn. Winter cover crops would add humus to enrich the soil. East Texas soils can be fertilised because of fairly well distributed rain through the growing season. The sandier soils are ideal cotton land. Exploitation of land in North-West Texas goes on from year to year and large-scale farming is carried on. [*Int. Cotton Bull.*, 1928, 6, 256-260. V. H. SCHOFFELMAYER.]

WOODHOUSE MEMORIAL PRIZE.

AMENDED RULES.

THE prize will be in the form of a silver medal and books of a combined value of Rs. 85 to be competed for annually under the following conditions :—

2 The competition is open to graduates of Indian Universities and to Diploma holders and Licentiates of recognized Agricultural Colleges in India who are not more than 30 years of age on the date of submission of their essays.

3. The prize will be awarded to the writer of the best essay on a subject of botanical interest, to be selected from a list which will be drawn up each year by the examiners, and published with an official notice regarding the competition published in the *Agricultural Journal of India*. Notices will also be sent to Departments of Agriculture and Universities in India.

4. The length of the essay should not exceed 4,000 words ; and the prize essay, if of sufficient merit, will be published in the *Agricultural Journal of India*. It must not be published otherwise without the sanction of the Director of Agriculture, Bihar and Orissa.

5. The examiners will be :—

(1) The Imperial Economic Botanist, Pusa.

(2) The Economic Botanist, Sabour.

(3) A Botanist attached to a Provincial Agricultural Department, who will be selected by the Trustees each year.

(4) A leading Botanist of an Indian University.

6. If no essay is sufficiently good, the prize will be held over and the money will go to increase the fund.

List of subjects for 1928 prize.

1. Modern methods of crop improvement by botanical methods.
2. The application of cytology to plant breeding.
3. The place of physio'ogical research in botanical science, as applied to crop improvement.
4. The importance of lower organisms to the growth of plants.
5. The technique of yield trials with special reference to Indian crops.
6. The problem of sterility in Indian crops and fruit trees.

Papers should be forwarded to the Director of Agriculture, Bihar and Orissa, Sabour, Bhagalpur, E. I. R. Loop, before November 1st, 1928.

Personal Notes, Appointments and Transfers, Meetings and Conferences, etc.

Mr. W. Smith, Imperial Dairy Expert, has been granted leave on average pay for three months combined with leave on half average pay for one month and twenty-seven days, with effect from the 18th May 1928.

Mr. Z. R. Kothawala, Assistant to the Imperial Dairy Expert, has been appointed to act as Imperial Dairy Expert, with effect from the 18th May 1928.

Mr. F. F. Traynor, Superintendent, Cattle Breeding Farm, Karnal, has been appointed to act as Assistant to the Imperial Dairy Expert with effect from the 18th May 1928.

Mr. J. H. Walton, M.A., M.Sc., Imperial Agricultural Bacteriologist, has been granted leave on average pay for three months combined with leave on half average pay for three months and fifteen days with effect from 1st May 1928.

On termination of his officiating appointment as Director of Agriculture, Punjab, Mr. H. R. Stewart has been appointed Officer on special duty in the Department of Agriculture for a period of two years with effect from the afternoon of 28th December 1927.

Mr. D. Quinlan, Director of Civil Veterinary Department, Bihar and Orissa, has been granted combined leave for 28 months, *viz.*, leave on average pay for five months and fifteen days and leave on half average pay for the remaining period, with effect from the 7th February 1928.

Mr. P. C. Choudhury, Deputy Director of Sericulture, Bengal, has been granted leave on average pay for one month from the 3rd May 1928.

MR. D. BALAKRISHNAMURTI GARU, Vice-Principal, Agricultural College, Coimbatore, has been granted leave on average pay for two months and ten days and in continuation thereof leave on half average pay for two years, one month and twenty days.

MR. P. H. RAMA REDDI GARU, M.A., B.Sc., Deputy Director of Agriculture, III Circle, Bellary, has been appointed Vice-Principal, Agricultural College, Coimbatore, from 21st May 1928, *vice* Mr. D. Balakrishnamurti Garu granted leave.

MR. G. N. RANGASWAMI AYYANGAR AVERGAL, B.A., Millets Specialist, Madras, has been granted leave on average pay for one and half months from the date of relief.

MR. R. C. BROADFOOT, N.D.A., Deputy Director of Agriculture, VI Circle, has been appointed Cotton Specialist, from 1st May 1928, *vice* Mr. G. R. Hilson granted leave.

MR. A. WILSON, on returning from leave, has been posted as Deputy Director of Agriculture (Cinchona) in relief of Mr. H. Wheatley.

REVIEWS

Plant Nutrition and Crop Production.—BY SIR JOHN RUSSEL, F.R.S. UNIVERSITY OF CALIFORNIA PRESS, BERKELEY, CALIFORNIA.

THE Hitchcock Lectureship in the University of California was established in 1909 by the generosity of the late Charles M. Hitchcock of San Francisco for the purpose of giving the public an opportunity of hearing lectures on popular and scientific subjects. The appointment of Sir John Russell to this lectureship in 1924 was the first occasion on which agricultural science was chosen as the subject.

The course consisted of five lectures which cover the whole field of plant nutrition. In each lecture one aspect of the question is considered. Thus in the first chapter the materials on which the plant feeds are discussed. The subject is treated historically and a very interesting account is given of the scientific views prevalent before Liebig's work did away with the mystery attaching to the food of plants. Liebig's researches, which showed that only simple mineral and gaseous substances were involved, attracted the attention of a young English squire, John Bennet Lawes. This young landholder combined a keen experimental turn of mind with business and farming instincts, while his youth coincided with the period of terrible distress which followed the long series of European wars. Lawes, faced with the necessity of obtaining a higher return from his estate, experimented among other things on manures to increase the yield of his crops. He not only obtained confirmation of the value to the plant of phosphates and alkali salts but he also extended Liebig's work by demonstrating the importance of nitrogen compounds. Lawes first made his " patent manure " in a barn at Rothamsted but later set up a factory at Deptford. At the same time he started a series of experiments on agricultural science—the Rothamsted experiments. As the work of the factory and of the Experiment Station was too much for one man he selected a young chemist, J. H. Gilbert, to help him. The success of their collaboration was so great that by 1855 the British farmers subscribed to build the laboratory in which these two pioneers worked to the end of their lives. This was the beginning of the great development of artificial fertilizers. The dependence of Europe on these substances, however, produced another anxiety. How long would the visible supplies of nitrogenous fertilizers last ? This fear was removed by the production of nitrogenous manures from the nitrogen of the air.

The practical application of these artificial manures has given rise to fresh problems. Individual fertilizers vary in effectiveness with changes in the soil and the season. The habit of growth of the plant or its composition may be affected and thus the response to differences in environmental conditions may be modified. The effect of nutrients depends, moreover, on the period of growth in which the nutrient is presented to the plant.

Another set of problems arises from the fact that the plant nutrients can only be given in combination with other things and the action of these other constituents may be deleterious. This factor assumes importance when considering the cost. Farmers are obliged to use the cheapest fertilizers available but the choice of the actual compound is often dependent on this indirect action of the constituent which is in combination with the desired nitrogen. Recent investigations on the effect produced by minute quantities of certain elements such as iron, boron and manganese are also discussed.

The second lecture is entitled *Positive Science and Exact Demonstration.* For many years investigators have been trying to give mathematical expression to the facts of plant nutrition but with only partial success. Liebig's simple curves, Blackman's idea of limiting factors and Mitscherlich's Wirkungsfactor are discussed by the lecturer. An account is also given of the new statistical method which is now being developed at Rothamsted under Fischer. An interesting review of the question of farmyard manure *versus* artificial fertilizers follows.

In the third chapter, *Decay and the living plant*, the decomposition of plant residues and farmyard manure with the formation of humus is discussed. The rise of soil bacteriology is described and the most modern developments in research on nitrogen fixation and soil organisms in general are dealt with. The fact that energy relationships play a considerable part in determining the reactions brought about by micro-organisms in the soil is emphasized.

The control of the soil micro-organisms forms the subject matter of Chapter IV. Three methods are in use : (1) the introduction of special micro-organisms, (2) the modification of the soil conditions to favour or discourage the development of particular organisms, (3) attempts to kill organisms which are not wanted. The first method is illustrated by the inoculation of the soil for lucerne. The difficulties encountered and the success attending the use of milk as the inoculating fluid and the addition of small quantities of phosphate is described. An account of the manufacture at Rothamsted of artificial straw manure without using animal excretions and also of the results obtained by the partial sterilization of the soil follow.

In the last chapter, *the structure and composition of the soil* itself is described in the light of the most recent investigations. The mineral phase, the organic phase, the presence or absence of reactive calcium, the question of tilth, the presence of colloids, the formation of alkali soil, the nature of the soil atmosphere and of the soil solution all receive attention. [G. L. C. H.]

Seed Production and Marketing.—By JOSEPH F. COX AND GEORGE E. STARR. [New York : JOHN WILEY AND SONS ; London : Chapman & Hall.] Price, 20*s*. net.

Seed is of such primary importance to agriculture and the production and marketing of seed involve so large a capital investment in Europe and America

that no apology is needed for the appearance of this book. The book is written chiefly on American experience and should prove of great practical utility in that country. In India we are still a long way from the realization of the importance of pure seed and there are not in this country any commercial organizations interested in the supply of pure seed to the cultivator on a large scale. Almost the only work of this nature has been that carried out by the various departments of agriculture in distributing seed of the improved varieties of crops which have been bred by the scientific officers of the departments. The book therefore describes a state of affairs which we may hope to see realized in India, at some not too distant date, but which unfortunately is not at present a matter of practical concern to the Indian ryot.

The first four chapters of the book deal with modern methods of seed breeding and the special cultural practices and equipment necessary in growing good seed. A chapter is devoted to the description of the work of crop-improvement associations and co-operative seed distributing agencies. These associations have been developed as a result of the realization by American agriculturists of the principles of crop improvement. The American agriculturist realizes that, in spite of great merit, new varieties have small chance of achieving widespread distribution unless the seed is increased in quantity, kept pure and sold at a reasonable price. If seed of a new variety is released in small lots from the plant breeder it will in most cases become mixed and fail to effect any real improvement. It is therefore essential that there should be an organization for the multiplication of pure seed distinct from that organization which is charged with the production of new types by plant breeding. In America this is achieved largely by the formation of associations of growers who are interested in the production and selling of the best seed. These associations require field and after-threshing inspections and through their inspection service affix seals to bags carrying seed meeting their high requirements. Such seed is known as "certified seed," since it has been inspected and certified as to variety and purity and germination on a specified date.

The last twenty chapters in the book describe the growing and production of seed of the chief crops of the United States of America. They are not of such practical importance to the Indian agriculturist as are the principles which are laid down in the opening pages. [F. J. F. S.]

Green Manuring : Principles and Practice.—By ADRIAN J. PIETERS, Ph.D. Pp. xiv + 356 ; illustrated. (New York : JOHN WILEY & SONS ; London : Chapman and Hall.) Price, 22*s.* 6*d.* net.

" The problem before the man who farms the poor lands of the Atlantic Seaboard and the one on the wheat lands of eastern Washington is in one respect the same—the increase of organic matter in the soil."

The Indian agriculturist has to face the same problem, perhaps in a more acute form, for such organic matter as he does supply to the soil disappears faster than it does in more temperate climates, and cattle dung, which would otherwise be applied to the land, is often the only source of fuel suited to his customs and needs. In such a district as North Bihar, where owing to the decay of the indigo industry, the large quantities of "seet," the indigo plant after extraction of the dye, which formerly used to be applied in a well-rotted condition to the land, cannot now be obtained, the problem becomes even more acute. One way to solve this problem is by green manuring.

All who are interested in the maintenance of soil fertility in India will be indebted to the author for his valuable and comprehensive treatise. Dr. Pieters describes himself as a compiler, rather than an original worker in the field of green-manuring, but his work is more than a mere compilation, for it includes much discussion of results obtained by the investigators whose work is referred to in the text, of which there is a bibliography containing 352 references. This bibliography is very full, and should prove a most valuable aid to those who wish to know further details of work which could necessarily be only briefly summarized in this volume.

The author does not recommend green manuring as a universal remedy for low production. To quote again from his introductory chapter, "it is not meant that green manuring will solve the production problems of the future, but that it is one of the methods by which the productive power of the soil may be increased or maintained. Green manuring will take its place beside tillage, crop rotation, improved varieties, and the use of fertilizers, * * "

After the Introduction and a brief chapter on the History of Green Manuring, the author deals with the organic matter and biochemical activities of the soil, the nitrogen problem, and nitrogen fixation, symbiotic and non-symbiotic, in Chapters III--V.

The next three chapters are concerned with the chemical composition of green manures, their decomposition in the soil, and their effects in the soil, other than the addition of nitrogen. Chapter IX is entitled "Various practical considerations." This includes inoculation of legumes, time and depth of ploughing, effect of some crops on those following, factors limiting the use of green manures, etc.

Examples of the yields obtained after green manuring are given in Chapter X, and the various crops used for green manuring described in Chapter XI. Chapter XII deals with the practice of green manuring in the United States and Chapter XIII with that in other countries, and there is a final short chapter on the economics of green manuring, in which questions such as the advisability of feeding a legume crop to stock or turning in under, of selling the hay or turning the legume under, and the comparative costs of green manure and stable manure are discussed. [J. H. W.]

Economic Aspects of Cane Sugar Production.—By Francis Maxwell, D.Sc., M.I. Mech. E., F.C.S. (Norman Rodger, 2, St. Dunstan's Hill, London, E. C. 3, 1927.) Pp. VIII+200; 16 plates including frontispiece and one sketch map of the world. Price, 12*s*. 6*d*. net.

We welcome this book as providing a mine of information on the cane sugar industry of the world together with a clear and concise statement of the advantages and disadvantages of each country. From a perusal of it we get a reliable idea of the reasons which make Java so super-efficient in the price question, Hawaii so exceptionally well organized and developed on all sides, Cuba able to keep her end up despite all the rough and ready methods applied to her cane supply, and last but not least Queensland staggering under the most appalling labour costs, the penalty of a White Australia policy, nevertheless able to lead the world on the sugar to cane factor where at 7·80 she holds a lead of 0·4 over her nearest competitor. The industry in India and the general cane conditions here are dealt with in the first chapter, and it is most refreshing to find that at last it has been able to find a place in a standard book of reference, and the details given are in accordance with facts and give the reader a fair and true idea of when the real difficulties in the way of establishing a sugar industry in India are.

Outside of the ordinary details connected with agriculture and manufacturing the agreements between growers and the mill in various countries are given and a wealth of detail regarding the labour conditions in the various countries. The only point which one feels has not been so fully dealt with is the all important one of price. The author tells us what the various countries can produce at. A brief scrutiny of these figures and the figures prevalent for the last 12 months in the leading sugar markets of the world force one to the conclusion that either radical economies have been effected or else such figures have no real value. If this is not so, the sugar industry in most of the world must be an expression of philanthropic goodwill to the consuming public on behalf of various large banks and financial magnates. Leaving aside this point, the book is well put together and contains a large mass of valuable notes and facts and should be found in every sugar library. [W. S.]

Indian Agriculture.—By A. Howard, C.I.E., M.A., and G. L. C. Howard, M.A. India of Today Series, Vol. VIII, pp. 98, Oxford University Press.

In this booklet Mr. and Mrs. Howard with a considerable measure of success have made an attempt to give a succinct account of the position of agriculture in India, of the results of the efforts of the agricultural departments to improve agricultural practice, and of their ideas regarding the best means of unifying all the various official efforts and of encouraging the co-operation of all concerned both directly and indirectly with agriculture and the handling of its products and accessories, with the ultimate aim of placing the people in a position where they can esti-

mate the value of methods and choose what is within their means to apply for their own advantage.

The importance of agriculture to the welfare of India is shown statistically by a consideration of the occupational distribution of population, the areas under the important crops, the yield of these crops and the value of the surplus for export. A chapter is devoted to a summary of the development of the Agricultural Departments from 1904 when Lord Curzon sanctioned the formation of an Imperial Research Institute at Pusa till 1925 when the budget provision for all the agricultural departments was 1,07,64,228 rupees, and in the appendix is a short directory of these departments. The succeeding chapter indicates a few of the main practical results of agricultural research obtained since 1904. Some of them are striking. One example will suffice. All the departments have paid much attention to the distribution of improved varieties of seed and in 1925-26 they are said to have been grown on an area of 7,412,857 acres giving an enhanced value of seven crores of rupees.

The main factors underlying Indian agriculture which have been closely studied during the last twenty years are briefly dealt with and the fact brought out forcibly that the monsoon is the dominant factor in rural India. Not only does it influence the crops grown and the fertility of the soil but its uncertainty and unequal distribution have induced a marked fatalism in the cultivator and a lack of desire to improve his condition. He is uneducated and unprogressive with no desire for a better condition of life in the shape of improved crops, implements and cattle, better communications, efficient schools and wider markets. Simultaneously with efforts made directly to improve his material prospects education is absolutely necessary both for the children in schools and for the adult in the broader aspect of his relation to his environment.

The authors then develop the idea that rural development should be dealt with as a whole and not by various departments as at present. A concentration of effort is needed and a number of independent movements—the extension work of the Agricultural and Veterinary Departments, the Co-operative Credit Movement, and that portion of the Educational Department that deals with primary rural schools—should be at once combined into a single agency and later on should include all the other organizations that deal with the countryside such as those concerned with the distribution of irrigation water and with roads, markets and rural sanitation. This agency they designate as the Development Board of Rural Reconstruction. There have been tendencies in various parts of India to co-operate and combine but the suggestion is that this should become a definite organized policy. It is a booklet that everyone who wishes to have a bird's eye view of agriculture in India should read, and for those who have the leisure and the inclination to dip deeper into this most absorbing subject the bibliography at the end of each chapter indicates the best of the literature on each point. [W. M.]

NEW BOOKS

On Agriculture and Allied Subjects

1. The Oxford University Press proposes to bring out at an early date a Hindi translation of *Indian Agriculture*, by Albert Howard, C.I.E., M.A., and Gabrielle L. C. Howard, M.A., (India of To-day Series, Volume VIII). As the Hindi edition is for the most part a subscription edition, only a few extra copies for sale to the public will be printed. These copies will be sold at Rs. 2-8-0 per copy. Orders should be placed with the Manager, Oxford University Press, Post Box 31, Bombay.
2. An A B C for the Young Tea Planter, by A. F. T. Stevenson. Thacker Spink & Co., Calcutta. Price Re. 1.
3. The following publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Memoirs.

1. The Indian Types of *Lathyrus sativus* L. (*khesari*, *lakh*, *lang*, *teora*), by Gabrielle L. C. Howard, M.A., and Khan Sahib Abdur Rahman Khan. (Botanical Series, Vol. XV, No. 2.) Price, Rs. 1-8 or 2*s*. 6*d*.
2. Studies on Rice in Sind, Part I, by K. I. Thadani, M.Sc., and H. P. Durga Dutt, B.Sc. (Botanical Series, Vol. XV, No. 6.) Price, Re. 1 or 1*s*. 9*d*.
3. Studies in Gujarat Cottons, Part V, by H. H. Mann, D.Sc., and M. L. Patel, M.Ag. (Botanical Series, Vol. XV, No. 7.) Price, As. 14 or 1*s*. 6*d*.

Bulletins.

4. The Stem-bleeding Disease of Arecanut (*Areca catechu*) caused by *Theilaviopsis paradoxa* von Hon., by S. Sundararaman, M.A., C. Krishnan Nayar and T. S. Ramakrishnan, M.A. (Bulletin No. 169.) Price, As. 9 or 1*s*.
5. Unit system for Farm Buildings, by G. S. Henderson, N.D.A., N.D.D. (Bulletin No. 174.) Price, As. 5 or 6*d*.
6. A Method of Increasing the Manurial Value of *Mahua* Cake, by N. D. Vyas, L.Ag. (Bulletin No. 176.) Price, As. 4 or 6*d*.
7. The Orange. A Trial of Stocks at Peshawar, by W. Robertson Brown. (Bulletin No. 93 Revised.) Price, Rs. 1-5 or 2*s*. 3*d*.

Report.

8. Report of the Imperial Institute of Veterinary Research, Muktesar, for the year ending 31st March 1927. Price, As. 10 or 1*s*.

MGIPC—M—III-1-61—26-7-28—1,670.

ORIGINAL ARTICLES

NOTES MADE ON A TOUR IN EGYPT.

BY

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AND

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ITINERARY.

LEAVING Naples on the afternoon of Friday, September 30th, we reached Alexandria at 7-30 A.M. on Monday. As soon as the steamer got into harbour, a police officer sent by the Ministry of the Interior came aboard and saw to the landing of our luggage. Later on, we were met by Dr. W. Lawrence Balls, F.R.S., and Alphonse M. Greiss Bey, Director of the Agronomic Section of the Ministry, who had been deputed by the Minister of Agriculture to guide us in our Egyptian tour. They were accompanied by a Secretary, Afif Habra Effendi, by a representative of the Governor of Alexandria, and a representative of the High Commissioner.

After landing we had a free day and used the opportunity for getting general information from our guides. Thereafter until we left Cairo at 6 P.M. on the 11th, every hour of the day was occupied. We started from our hotel at various times between 7 and 8-30 A.M. and rarely got back until after 7 P.M. Our guides mapped out for us a most interesting programme, and the Egyptian Government did everything possible to make our visit instructive. Tuesday, the 7th, was spent in seeing something of cotton marketing in Alexandria and land reclamation at Aboukir Bay; Wednesday and Thursday in visiting institutions in Cairo; Friday and Saturday in an expedition to the State Domains and the Ministry's experimental farm in the heart of the Delta. On Sunday we saw something of the irrigational and other activities of the Public Works Department, and visited the farm of the Royal Agricultural Society. Monday was spent in a visit to Faiyum province. Tuesday was set aside for general sight-seeing and we exchanged modern for ancient agriculture: after inspecting the Tutenkamen relics, we visited a tomb at Sakkara on the walls of which the Egyptian agriculture of 3,000 B.C. was effectively portrayed.

STATISTICAL INFORMATION.

In the appendix (p. 339) will be found some figures relating to the resources of the Egyptian Government, the area of the country, the areas under the more important

crops, the yield of the crops in the past three years, live stock figures, distribution of holdings and population. It will be noted that nearly 4 per cent. of the total expenditure of the Egyptian Government is devoted to agricultural and veterinary subjects, 6·8 per cent. to education and 3·7 per cent. to public health.

As regards the distribution of holdings, it will be seen that of the 2,039,000 owners of land in Egypt, about 1,884,000 own 5 feddens and under. Agriculture is the main occupation of the people. In a population of 11,000,000 (excluding children under 5 years of age) recorded at the census of 1917, 4,000,000 were engaged in agriculture. The following additional figures are of interest. The cost of living index in Egypt varied from 159 in January 1924 to 171 in February 1925 and fell to 159 in June 1926. Per head of the population the consumption of some leading foodstuffs was as follows :—

	Kilograms
Wheat	84·2
Maize	134·1
Rice	9·8
Beans	20·2

The artificial manures imported in 1926 were :—

	Metric tons
Nitrate of soda	174,000
Nitrate of lime	14,500
Sulphate of ammonia	9,500
Cyanamide	970
Superphosphate of lime	56,000
Others	3,700

It may be noted that the exportation of organic manures from Egypt is prohibited.

LOCAL ADMINISTRATION.

The six chief towns of Cairo, Alexandria, Port Said, Damietta, Ismailia and Suez are under Governors, as are also the 14 provinces of cultivated Egypt. The Governor of the province, or Mudir, is assisted by a provincial council of which he is President. The council is made up of two representatives of each *markaz* or administrative sub-division, of which there may be from three to ten within the province. These councils have extensive powers in connection with education, and can apply the whole of the local contributions voted by the council to educational schemes. They have power to vote local contributions for purposes of public utility up to 5 per cent. of the land tax of the province. The money may be spent as they desire, but the annual budget which they vote must be approved by the Minister of the Interior. The council has power to apply or veto certain Government decrees having local application ; they also regulate the markets and fairs within the province.

In connection with certain villages and small towns, village councils have recently been created. There are now 46 such councils in Egypt. The village council consists of the President of the *markaz*, the Public Health Inspector and four elected members. The Governor of the province, if he chooses, has the right to preside. These village councils have been created largely with the object of educating Egyptians in local administration.

Ministry of Agriculture.

The Ministry of Agriculture, in addition to a general administrative service, has sections for statistics, commerce, agronomic subjects, publications and engineering. Recently the Minister has established a large consultative council on agriculture, consisting of eight official members, and twenty-one non-officials selected by the Minister himself. He has also set up a technical consultative committee consisting of the Permanent Secretary of the Department, the Chief Inspector and the Directors of the technical sections. This committee meets monthly to co-ordinate the work. In 1919 there was created a Cotton Research Board to promote investigation on cotton subjects. Nominally the technical laboratories of the Ministry are controlled by this Cotton Research Board, but the Board does not take a very active part in administrative details. For the actual work in progress the technical officers are responsible.

The Commercial Section of the Ministry is mainly concerned with the distribution of seed-cotton on credit to small fellaheen. It also sells manure on credit. Payment is collected with the land tax. It may be noted that the supply of seeds and manures was first undertaken in Egypt by the Royal Agricultural Society and that much of the work is still in their hands ; but the Society deals with those fellaheen who are able to pay cash ; the Ministry can afford to give credit, since it has facilities for collecting debts which are not open to the Society.

The Agronomic Section manages a series of experimental farms, controls field experiments, organizes the work required for the propagation of pure strains for the improvement of agriculture. We visited one of the experimental farms, that at Guimeza.

We did not see anything of the activities of the Publications or of the Engineering Sections of the Ministry, but had an opportunity of visiting several of the technical sections.

In Egypt, as in Holland, most agricultural activities are conducted from one centre, the main difference between the organization in the two countries being that in Egypt the Royal Agricultural Society appears to take a much larger part in promoting agricultural improvement than do non-official bodies in Holland. Corresponding to the phytopathological service in Wageningen, there is in Cairo a Plant Protection Section of the Ministry with an office in the town and laboratories at Giza. The importation of cotton plants and seed of vines, and of several other products, is strictly prohibited, and certain fruits and vegetables can only be im-

ported after examination. The Section has well equipped laboratories at Giza. In the entomological laboratory alone about eight entomologists are employed, cotton pests naturally receiving chief attention. There is also a special laboratory for studying injurious fungi ; it has recently been staffed wholly by Egyptians, but on the day of our visit we found that a botanist from Kansas (who had specialized on immunity in plants) had just begun work there under contract with the Government. The Plant Protection Section is also charged with the control of ginneries ; for, in order to prevent the spread of pink bollworm, all Egyptian cotton seed intended for sowing must be specially treated in the ginneries. The treatment consists in heating the seed to a specified temperature for a definite period in an approved type of heater. Four types of machine have hitherto been approved for the purpose. There are about 114 ginneries in Egypt and samples of the treated seed are regularly collected and examined in the section, so as to test the efficacy of the heating plant which the ginneries employ. A seed germination laboratory is also attached to this section.

Another of the technical sections deals with horticultural subjects, studies the acclimatization of new varieties, experiments on fruits and vegetables, provides technical advice for growers and conducts a number of experimental gardens in different parts of the country.

The Chemical Section undertakes the analyses of all materials required in agriculture, fertilizers, insecticides, sprays, feeding stuffs, and it is also at present engaged in studying the soils of the country.

The Botanical Section is the strongest of the group of technical sections ; it is engaged in selecting and improving cottons, wheat and certain other plants. The pure strains of cotton which are bred by this section are grown on by the Agronomic Section on one of their experimental farms, and at a later stage are transferred to one of the farms of the State Domains Administration. From twelve to fifteen botanical workers are engaged, and there was evidence of much activity in investigation. The section has at its disposal about 75 acres of experimental grounds and these were occupied chiefly by cotton, maize, wheat and berseem.

The Chemical, Plant Protection and Botanical Sections all occupy the same building, containing some fifteen or twenty laboratories and stand in the grounds of the Botanical Section. The facilities for field work, and the equipment of the laboratories, are excellent.

The Veterinary Section of the Ministry controls the Serum Institute at Abbasia. This is a large establishment in which a director and four professional assistants are engaged in preparing doses of serum and virus for the serum-simultaneous inoculation of cattle against rinderpest, which is now compulsory. A serum is also prepared against hæmorrhagic septicæmea. The method of preparing serum was ful y explained to us. About 30 Cretan cattle are imported each month ; these animals are selected because they are peculiarly susceptible to rinderpest. After being got into good condition in an isolation hospital, they are infected with virulent

blood, and in six days or so are severely attacked by rinderpest. In the compound of the institution there are maintained some 120 to 150 Egyptian bullocks which are hyper-immunized and from them the serum for distribution is prepared. These animals live in the hospital from six to ten years and are regularly used in serum preparation. The method employed in getting the serum is as follows: when the imported Cretan cattle develop fever to the required point, they are bled to death; then infected blood is injected into the Egyptian cattle which have acquired a great degree of immunity so that the injection does not disturb them much. After a few days two litres of blood are extracted from each of the Egyptian cattle and used to prepare the serum. The clotted blood is shredded, and the serum is extracted by a centrifugal machine. We are informed that the necessary dose of serum costs from 11 to 14 piastres, that roughly 60,000 cattle were inoculated per annum, and that the total cost of running the institution was about £E.10,000. The purchase of Cretan cattle is an expensive item. We gathered from the Inspector in charge of the Institute that, in practice, compulsory inoculation involves the field staff in no serious difficulties. Inoculation is now readily accepted by the fellaheen. Fever lasts from three to four days, and working bullocks require a 15 days' rest after treatment. Cows go off their milk temporarily, but there is no permanent effect. The inoculation is carried out by trained veterinary surgeons; the number of deaths following inoculation is now negligible. The Institute maintains a stock of about 350,000 doses of serum which is kept in a cold store in Cairo, and sent to the country as required in ice chests.

The Publications Section of the Ministry supervises the preparation of the technical reports and bulletins of the Ministry and is also charged with the translation into Arabic of scientific and other books and reports. Teaching in the School of Agriculture is now in Arabic, and an effort is being made to substitute this language for English in all publications of the Ministry. At present, however, a number of publications are also issued in English, or in French.

Policy of the Ministry.

The present Minister, Barakat Pasha, a nephew of Zaghlul Pasha, is himself a fellah by origin, a keen nationalist and an idealist. He has framed a very comprehensive agricultural policy which he has remitted to an expert committee for criticism. The following extracts from a statement of this policy which appears in the Government Almanack will indicate its comprehensive character —

"Ministry of Public Works should construct drains everywhere and repair existing ones. Enormous sums of money should be allotted for the employment of specialists of whatever nationality in order that plant pests may be controlled. Government should offer large financial rewards against these pests. Advertisements to this effect should appear everywhere. Money must be allotted for employing botanists, for improving existing plants and introducing new ones. Experimental stations and farms for the multiplication of seeds are called for. Seed

farms for propagating selected cotton seed, cattle breeding in general and poultry in particular should receive attention. The number of students sent abroad for training should be largely increased : only 5 per cent. of those now studying abroad have been selected by the Ministry of Agriculture. Standard of education in agricultural and veterinary schools to be increased ; agricultural education to be introduced into the compulsory elementary schools and in other classes if possible. Farm schools should be established for instructing young men in gardening." When this policy was announced in 1924 seven new laws were adumbrated : the following four have already been enacted : (1) law to control the distribution of cotton seed for sowing ; (2) law prohibiting admixture of cotton ; (3) law restricting cotton cultivation to one-third of the area in an occupier's possession ; (4) law requiring compulsory inoculation of cattle. The other Acts which the Minister contemplates are (1) on agricultural co-operation, (2) on the organization of cotton exchanges, (3) on manure control.

ROYAL AGRICULTURAL SOCIETY.

We visited the Royal Agricultural Society, spent some time in examining the very interesting collections in the Cotton Museum, and from the Secretary of the Society obtained particulars about the growth and activities of this flourishing and highly useful body, which has done so much for the improvement of Egyptian agriculture. A note on the Society which was prepared for us by the Secretary is reproduced below.

" The Royal Agricultural Society was founded in 1898 under the name Khedivial Agricultural Society by the late Sultan Hussein, its first president (then Prince Hussein Pasha Kamal) with the assistance of certain members of the Royal Family in Egypt and eminent Egyptian cultivators.

Its object is to improve and develop agriculture in Egypt, by all possible legal means. Its Statutes were drawn up in the year of its formation, 1898, and since then the Statutes were revised in 1901, 1905, 1911, 1915, 1917 and finally in 1924.

The Society has been since its formation in close touch with the cultivators, and each province (Mudiria) has a representative on its Administrative Council.

Until 1911—when the Government established an Agricultural Department—the Society had Agricultural Committees in all provinces and big cultivators of each province attended to explain their demands, express their wishes and make suggestions, before the officials of the Society, the Inspectors of Irrigation and Health, and Governors (Mudirs). The decisions passed were communicated to the Administrative Council for consideration and perusal.

Until the time when the Agricultural Department—eventually becoming the Ministry of Agriculture—was established, the Society was the source from which agricultural laws were created.

The Society studied the question of decrease in cotton yield, obtained a decree for destruction of the cotton worm, organized agricultural and industrial exhibitions, acted for the protection of birds useful to agriculture, called the Government's

attention to the necessity of fumigating seeds coming from abroad and the non-transport of unginned cotton from Upper to Lower Egypt and started propaganda for the formation of agricultural syndicates and co-operative funds, calling on the Government on every occasion for the necessary laws and regulations governing same.

Besides, the Society made various experiments in different localities in Egypt for improving and propagating cotton seed, studying, at the same time, the nature of injurious insects and botanical diseases; the breeding of cattle and horses and several other valuable services, which the Government and the cultivators highly appreciated.

The Society, realizing the importance of chemical fertilizers, introduced them into Egypt in 1901, and undertook to protect cultivators from adulterated manures, impressing on the Egyptian Government since 1909 the necessity of passing a law against adulteration of manures, which law, after long study, is expected to appear shortly.

The Society was the first to import into Egypt chemical manures, after many experiments, with the object of increasing the yield of agricultural crops. It was not intended to make the chemical manure replace the farmyard manure, etc., but to make up for the shortage of same, showing on every occasion the importance and necessity of relying on natural and local manure. As nitrate of soda, the most common in use, can easily be adulterated, the Society created means by which its Inspectors in the provinces can chemically and physically examine this manure and quickly detect the adulteration, if any has occurred.

As it was necessary for the Society to have an income which would enable it to continue its service, the Society adopted a method for selling manure and seeds at a certain profit which would cover its expenses and gradually increase its capital.

Appreciating the Society's valuable services to cultivators, the Government in the early years of its formation used to give to the Society yearly grants until 1914 (at the break of the great war), as well as a loan to help the Society to buy the necessary quantities of chemical manures, and sometimes guaranteed the Society to the National Bank of Egypt for amounts borrowed; the Government also helped the Society in distributing manure to small cultivators on privileged terms, a practice that has been lately undertaken by the Government itself.

Besides the above, the Government supported the Society in organizing agricultural and industrial exhibitions in Cairo and in the provinces, and offered plots of land for agricultural experiments. To the support thus given, a great part of the Society's success is due.

The Royal Agricultural Society is not affiliated or attached to any other society or syndicate, and is absolutely independent in carrying out whatever researches or other work attached to agriculture, since the Government grants were suspended by mutual agreement between the Egyptian Government and the Society. It is not a co-operative society, yet it follows a co-operative system with cultivators.

The Society is composed of 400 active members who issue resolutions which are submitted for approval to the annual general meetings. Adherent members of an unlimited number are also admitted to the Society.

All members (except in elections) enjoy equally the same rights. They have the privilege of certain reductions in prices of manures and seeds, but they have no shares in the Society's funds or in its profits or losses.

The greater part of the Society's capital was obtained from profits resulting from sales of chemical manures, year after year, and also from grants which the Government extended to the Society in its early years as previously explained.

Article 21 of the Statutes of 1924 (as well as former Statutes) stipulates that in case the Society is to be dissolved, the General Assembly will appoint liquidator or liquidators, and any money realized on the assets is to be used for forming a Society or carrying out a project for the agricultural benefit of Egypt, pending the decision taken by the General Assembly and approved by the Government.

The work of the Society is divided into four principal Sections, namely :—

(*a*) The Administrative and Commercial Section. It comprises the distribution of chemical manure and seeds.

(*b*) The Breeding Section for breeding cattle stallions and poultry.

(*c*) The Technical Section for agricultural experiments on all farm crops, chemical researches on lands and irrigation water, entomological studies, chemistry, botany, etc.

(*d*) The Cotton Museum Section for exhibiting everything relating to plantation of cotton, its industry, insect and fungus attacks and remedies, statistics, plans, etc., etc.

The capital of the Royal Agricultural Society (or the general reserved fund) amounted at the end of February 1927 to £E. 482,887 besides a special reserve of £E. 41,129 (including £E. 14,492, being cost of animals and poultry) and £E. 84,296, value of the Society's properties.

There are no shareholders and the capital belongs to the Society itself."

The relations between the Ministry and the Society are of a most amicable kind ; although to some extent their activities overlap, there is no jealousy, and in the commercial sphere the division of functions is that the Society sells manures to those who are able to pay cash, while the Ministry undertakes distribution on credit to small cultivators. It is estimated that about half the manure used in the country is supplied by the Society, about one-quarter by Government and about one-quarter by private traders. The present President of the Society, Mr. Mosseri, is an enthusiastic cotton improver and has written much on the subject.

School of Agriculture.

Until recent years the school of agriculture at Giza (which in England and India we should term an Agricultural College) was under the Ministry of Agriculture,

but in 1923 it was transferred to the Ministry of Education. The school provides a four years' course and at present has about 160 students. The accommodation now available limits the entry to about 40 in each year, but alterations are being made in the school, and when they have been completed, a class of 80 can be admitted. The Principal has no doubt that the demand for agricultural education will justify provision for as many as 80 students in the first year's course. It may be noted, however, that nearly all the students look forward to employment under the Government; less than 10 per cent. go back to the land, and while the Egyptian Departments have been expanding rapidly in recent years, it seems doubtful if so large a college will justify its existence. The cost to the State of each student trained is about £E. 750. Students usually enter at the age of from 18 to 20, having passed the secondary certificate of the Ministry of Education. A farm of about 70 feddans provides facilities for practical work; 12 hours a week are given to practical work in the first year, 8 hours in the second and third, and 12 in the fourth year. In the final year part of the practical work consists in supervising the field labourers, so as to give the student practice in controlling labour. The instruction is in Arabic, but English text-books are mostly used and all the students read English. There is no official relationship between this institution and the Ministry of Agriculture's technical departments.

The College for Veterinary Medicine adjoins the Agricultural College. It has accommodation for about 60 students and provides a four years' course. It grants a diploma of "veterinary surgeon of Egypt" which enables the graduates to practice within Egypt, but not elsewhere. Representations are being made to the Royal College of Veterinary Surgeons on this point. All the students so far turned out have been employed by the State; they enter the service at £15 a month and the best appointments in the veterinary service are worth £100 per month. The total number of qualified veterinary surgeons in Egypt is about 160. In the opinion of the Principal a large extension is necessary, as there are about 1½ million cattle and buffaloes in the country. State veterinary surgeons are allowed to take private work, the Principal views this concession with disfavour; if officials confined themselves to their proper duties, there would be scope in Egypt for the private veterinary surgeon, which at present there is not. The college maintains four whole time and eight temporary teachers. A small fee of £10 per course is charged and the cost per annum is about £6,000 or £100 per student. This college, like the other, is under the Ministry of Education who appoint a governing body or council of 9 persons to supervise it.

General education.

We had few opportunities of gaining information about the general education of Egypt, but when at Sakha we visited an elementary school. Children came from the Sakha estate. The school had four teachers, about 130 boys and 30 girls,

The boys are divided into two groups; one group comes in the morning and works in the field in the afternoon, the other works in the morning and comes to school in the afternoon. We were told that there was no such rapid falling off after the first class in Egyptian schools as in Indian schools, but 40 boys were counted in Class I in this school and in Class II, 17 only, so that it would appear that at Sakha conditions are not very different from those in India. The children were all well fed and well clothed; they appeared to be intelligent and when called on to recite from the Koran exhibited no hesitation or shyness, but recited their parts vigorously. On remarking to one of our guides that no indications of under-nourishment were observable, we were assured that in Egyptian rural districts all children were sufficiently fed.

There are in Egypt both "elementary" and "primary" schools under the Ministry of Education. The elementary school is a provincial institution, or a school supported from religious endowments. There were, in 1925-26, 337 officially so classed; the instruction is entirely in Arabic and is given to pupils between the ages of 5 and 14 who are grouped in four classes. There were, in addition, under the Ministry 43 schools classed as primary; the course lasts for five years; instruction is given in Arabic, but English is also taught as a foreign language. The number of pupils at these schools in 1925-26 was about 16,000. The Ministry supports 15 secondary schools for boys. These schools are attended by about 7,800 boys, who to gain admission must pass through the primary course. After three years' attendance a boy may choose between the literary or the scientific side of the secondary school. The total number of candidates who presented themselves for the secondary schools certificate in 1925 was 2,600, the successful candidates being about a thousand.

Educational missions.

It is interesting to note that the Egyptian Government now has 500 to 600 students studying in foreign universities. These students are selected by special committees and are placed under the general supervision of the Ministry of Education, who arrange for courses of studies in Europe and America at an average cost of £300 to £330 per head per annum. The purpose is to train Egyptians for the Government service and those who have returned from foreign study have so far been appointed to posts at £20 a month as a minimum. A young medical or a legal man who had come direct from the Egyptian university would, we were informed, be likely to earn £15 per month on receiving a first appointment.*

(To be continued.)

* For a list of students on mission from various Departments of the Egyptian Government in 1927, and the estimated cost of their education see the Appendix.

APPENDIX.

(a) *Budget of the Egyptian Government for the financial year 1927-28.*

	£
Total revenue	36,276,550
Taken from the reserve	2,642,450
Total expenditure	38,919,000

	£
Agriculture and Veterinary	1,500,369 = 3·9 per cent.
Education £2,663,204 = 6·84 per cent.—	
Primary and Secondary	2,160,125 = 5·55 ,,
Higher	340,260 = 0·87 ,,
Central Administration	162,819 = 0·42 ,,
Public health	1,078,463 = 3·7 ,,
Communications	8,879,643 = 22·82 ,,

(b) *Area of Egypt (1925-26).*

(1 feddan=1·038 acres.)

	Feddans
Total cultivated area	5,461,713
Area under different crops—	
Shitwi (Winter) crop	3,882,370
Sefi (Summer) crop	2,304,011
Nili (Autumn) crop	2,117,084
Orchards and gardens	33,978
	8,337,443

(c) *Sub-division of crops.*

Shitwi (Winter) crop.

Wheat	1,475,456
Beans	414,044
Barley	320,711
Berseem	1,437,199
Vetches	20,345
Onions	36,404
Lentils	63,422
Flax	3,584
Qortum	2,445
Helba	73,699
Lupines	14,888
Chick Peas	1,394
Poppy	2,645
Other crops	16,134
	3,882,370

(c) *Sub-division of crops*—contd.

Summer (Sefi) crop.

Maize	5,843
Millet	179,755
Rice	184,290
Groundnuts	14,238
Sesame	9,655
Melons and water melons	36,792
Other vegetables	19,050
Cotton	1,785,702
Sugarcane	52,063
Henna	996
Others	15,627
	2,304,011

Nili (Autumn) crop.

Maize	1,985,692
Millet	74,972
Rice	39,548
Vegetable and other crops	16,872
	2,117,084

Orchards.

Vines	5,672
Mandarines and Oranges trees	8,124
Fig trees	2,578
Others	17,604
	33,978

(d) *Yield per feddan of various crops for the last three years.*

—	1924	1925	1926	Units
Cotton	4·27	4·32	4·48	Kantars of 45 Kilos.
Wheat	4·55	4·95	4·58	Ardebs of 150 ,,
Barley	5·44	5·73	5·71	,, 120 ,,
Beans	3·95	4·45	3·87	,, 155 ,,
Lentils	4·06	4·02	3·75	,, 160 ,,
Helba	3·34	3·35	3·16	,, 155 ,,
Onions	148	148	141	Kantars of 45 ,,
Maize	6·78	7·00	..	Ardebs of 140 ,,
Millet	7·90	8·45	..	,, 140 ,,
Rice	0·918	1·174	..	Daribas of 934·5 ,,
Sugarcane	742	694	704	Kantars of 45 ,,
Groundnuts	8·55	10·28	10·15	Ardebs of 75 ,,

(e) *Livestock figures for 1926.*

	Males	Females	TOTAL
Buffaloes	34,289	728,845	763,134
Camels	102,021	69,072	171,093
Cattle	247,918	429,076	676,994
Donkeys	310,200	428,462	738,662
Goats	127,559	402,413	529,972
Horses	19,734	16,733	36,467
Mules	12,609	10,249	22,858
Sheep	206,745	936,809	1,143,554

(f) *Distribution of holdings according to figures available in 1924.*

	Feddans	No. of owners
Up to one feddan	533,542	1,357,573
From 1 to 5 feddans	1,101,930	526,961
,, 5 ,, 10 ,,	560,946	82,677
,, 10 ,, 20 ,,	530,144	38,830
,, 20 ,, 30 ,,	288,522	11,835
,, 30 ,, 50 ,,	357,872	9,338
,, 50 and upwards	2,224,077	12,574
	5,597,033	2,039,888

(g) *Total population and repartition according to occupation taken from census made in 1917, as 1927 figures are not yet available.*

Occupation	No.
Agriculture and Fishery	4,044,458
Extraction of mineral materials	2,693
Industries	489,695
Transport	150,633
Commerce	280,562
Public force	46,231
Public administration	43,361
Free professions	142,971
Owners	136,327
Domestic work	2,578,744
Without definite professions	372,289
Unknown professions	2,676,100
	10,964,064*

*Excluding children under 5 years.

The total population of Egypt according to 1927 census is 14,168,572 and according to 1917 census 12,751,000.

(h) *Scientific Missions* (*Budget*) *1927-28.*

—		No. of mission students in year 1926-27	Grant	
1926	1927		1926	1927
			£E	£E
1	1	Foreign Affairs	150	1,290
50	47	Ministry of Finance	17,000	18,750
254	254	" " Education	90,055	90,055
28	33	" " Interior	11,000	11,000
44	61	" " Public Works	19,250	15,000
30	39	" " Agriculture	13,000	10,660
125	125	" " Communication	48,500	48,500
3	2	" " Justice	600	1,200
535	562		199,555	196,455
		Less—not expected to be spent	30,000	..
			169,555	196,455

NOTES 1. The Advisory Committee for Government Missions have the right to increase the number of missions, if there is a balance permitting such increase, provided that this does not cause an excess in the sum granted for the following financial year.

2. The Committee has the right to transfer a grant fixed for one Ministry, and add it to the grant allotted to another Ministry.

RESEARCH IN COTTON TECHNOLOGY IN INDIA, 1927.*

BY

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I. Introduction : The determination of quality of cotton.

The immediate aim of the Technological Laboratory is to provide facilities for determining the quality of raw cotton; the Laboratory thus forms the last link in the chain of agricultural research directed to improving the cotton crop of India. Improvement in cotton growing may be brought about in one or both of two ways, *viz.*, by increasing the yield of ginned cotton per acre, and by improving the quality of cotton grown. These two factors are the supreme agricultural factors determining the monetary return to the cotton grower, and a new type must lead to a substantial improvement in either one or the other before a recommendation can be made that it should displace any variety of cotton which at present finds favour. In order to ascertain whether any new variety is really better than the old, it is necessary to have measures of yield and of quality. The accurate determination of the yield of a cotton variety is of course a matter for the agricultural officer himself; and although this is by no means so simple as is often supposed, the determination of the quality of the lint presents even greater difficulties to him.

The final test of the quality of any material is its behaviour in use, and as cotton is for the most part eventually used in the form of woven or knitted goods, it follows that ideally the quality of a cotton should be judged by the service it gives when made into such goods. The situation is somewhat complicated, however, because a single variety of cotton is seldom used alone in the manufacture of any one style of yarn or cloth, and further, of any two varieties of cotton it may and does happen that one is more suitable for one purpose, and the second for another purpose. Evidently, therefore, the final judgment of the quality of a cotton can only be reached after all the possibilities of its use for different types of yarns and fabrics have been fully explored. Needless to say, a procedure of this kind is impracticable; probably the only approach to any such procedure has been the investigation of varieties for some specific usage, *e.g.*, aircraft fabrics, tyre yarns,—and then only of such varieties as experience has shown to be likely to give good results. Long experience has indeed shown that, generally speaking, good qualities of

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* From "Research in Cotton Technology in India, 1927," *Ind. Cen. Cotton Committee Tech. Lab. Bull. 13, Tech. Ser. No. 8*, April 1928.

fabric demand certain qualities in the yarns from which they are made. If therefore we spin a new variety of cotton into yarn, and ascertain—as we can—the quality of the yarn, we can with a fair degree of certainty predict what type of fabric it will be suitable for. It is for reasons such as these that the spinning test is almost universally adopted as being the only really practical test which provides a sufficiently trustworthy index of the quality of raw cotton.

As the spinning and other valuable properties of a cotton must obviously depend upon its physical and chemical characters, it would be expected that a prediction of the spinning value of a cotton could be made purely from a knowledge of such characters. But the fact is that the exact relation between the various fibre characters of a cotton and the spinning value of that cotton has always been somewhat of a mystery, and a mystery it remains at the present day. This statement may appear the more surprising when it is remembered that, in all cotton markets throughout the world, cotton is daily bought and sold by a hand-and-eye estimation of the fibre properties. It is true that when a cotton grader is dealing with cotton of a type with which experience has made him familiar, his skill in valuing it may at times appear almost uncanny. But it is another story when he is dealing with a cotton of a new type—a cotton which, in other words, is unlike any of the types to which he is accustomed; in these circumstances his judgment is very liable to error. On the other hand, it might be thought that the less subjective methods of the scientist should be more successful, and that he should be able to solve the problem by making exact measurements of the various fibre-characters. No doubt this is so, but besides actually measuring the characters, he has yet to decide the extent to which each of the many characters enters into the problem. Up to the present time, the cotton breeder has been guided by certain properties of the cottons which are known to be of some importance; but experience has shown that these properties are only an imperfect guide at the best, and that the relative values of a number of cottons are sometimes placed in quite a wrong order by a cotton breeder relying upon his measurements of these properties.

It was the absence of any reliable means of judging the qualities of cottons merely by reference to their physical or chemical characters that led the Indian Central Cotton Committee to instal a complete spinning plant in the Technological Laboratory, so that all types of cotton could be submitted to the only really practical test, *viz.*, actually spinning the cotton. The work of the Laboratory is not restricted, however, to the making of spinning tests; each sample of cotton is not only spun into yarn, and its spinning performance determined, but it is also submitted to an expert grader for valuation, and subjected to numerous fibre measurements. Thus each sample is subjected to all three tests for quality. It is by analyzing statistically the results of the fibre measurements and correlating them with those obtained from the spinning tests, that it is hoped eventually to solve the problem of the relation between the properties of a cotton and its spinning value. If this task can be successfully accomplished, it should prove possible

to lay down certain tests by means of which the cotton breeder may judge the quality of any new cotton he may produce, when the quality of it available is too small for a spinning test. How far progress has been made in the solution of this problem will be discussed in the next part.

As stated above, all research work carried out in the Technological Laboratory has its origin in the fundamental objective of ascertaining the quality of cotton. The pursuit of this single objective, however, has necessitated the consideration of a number of related problems arising in spinning procedure, sampling, yarn testing, and fibre testing. Some of these problems have already been investigated, and, as frequently happens in such work, the results have a much wider application than to the immediate Laboratory problem for the solution of which the investigation was originally undertaken. This occurs particularly in experiments on spinning procedure, as will be evident from a consideration of the results of the various researches of which accounts have been published in bulletin form during the past year.

The subjects dealt with in these bulletins will now be discussed under the following headings :—

(1) The desirability of marketing cotton in a clean condition ;
(2) The effect of the physical conditions in spinning ;
(3) The minimum weight of cotton needed for a spinning test ;
(4) The standard Indian cottons ;
(5) The seasonal variation of Indian cottons ;
(6) The relation between fibre properties and spinning value.

II. The desirability of marketing cotton in a clean condition.*

In an ideal world cotton would be supplied to the spinner in the pure state without any admixture of that foreign matter with which it is at present so often contaminated. But this utopian dream has never been realized. Indeed, for many years past the complaint has been frequently made that Indian cottons, as they appear in the market, are exceptionally dirty. As a consequence, mills unprovided with special machinery for removing the excessive dirt have been precluded from using some types of Indian cottons. It is but natural that Indian mills, having a supply of cotton at their doors, should have turned to this cotton to meet their needs, in spite of the large amount of foreign matter which it contains. Adapting themselves to the prevailing conditions, they have installed blow-room machinery in greater proportion than would be done by mills working solely on cleaner types of cotton such as American.

Ideally, of course, cotton should be picked clean, and every effort made to see that the cotton sustains no subsequent contamination, either by moisture, by

* "The Effect of Subjecting Cotton to repeated Blow-room Treatment," *Ind. Cen. Cotton Comm. Tech. Lab. Bull. No. 10, Tech. Ser No. 5*, September 1927.

dust being carried on to the heaps of the seed-cotton while it is being stored prior to ginning, or by defective ginning itself. If this ideal is to be accomplished on a practical scale, it must be financially worth while to all concerned. So far as cotton prices are concerned, therefore, the question arises whether any premium paid for cleaner cotton would be recouped in a higher price subsequently obtained for the cotton.

With conditions as they are, some ginneries found it expedient to equip themselves with machinery for cleaning the seed-cotton before ginning it. But even although the *kapas* or seed-cotton may be picked over by hand before ginning, and although *kapas* openers may be used in some cases, yet nevertheless the generality of Indian cotton continues to be marketed in bale form containing much foreign matter. Even some of the standard Indian cottons have been supplied to the Technological Laboratory in a very dirty condition. Dirty cotton gives rise to dirty yarn; its value is therefore depreciated. Hence the question has arisen: Is it possible to remove the dirt from the cotton by repeated treatment in the blow-room, without causing damage to the cotton or reducing the strength of the yarn which is subsequently spun from the cotton? To answer this question, an investigation was made of the effect of repeated treatment in the Crighton opener or in the scutcher, of some baled standard cottons containing a large percentage of foreign matter: these cottons were two Punjab-American cottons (289F and 285F), and the standard Westerns cotton (Hagari 25). A comparison was made of 2, 3, and 4 treatments respectively in the Crighton opener for each cotton. Punjab-American 289F was also given the normal 2 treatments in the Crighton opener, but successive samples were passed through the scutcher 3, 4, and 5 times. Duplicate lots of each cotton were subjected to each treatment and spun into three different counts of yarn. Thus, in all, 72 types of yarn were spun. In each case the behaviour of the cotton during working was observed, and a record kept of the number of ring-frame breakages; the amount of waste at each stage was carefully determined, and the various yarns were compared for strength, neppiness and evenness. On each type of yarn spun, 50 tests were made for counts and lea strength, 100 tests for single thread strength and extension, and 80 tests for twist; hence the whole investigation included 3,600 lea tests, 7,200 single thread tests, and 5,760 twist tests.

The effect of additional Crighton-opening. The results of these tests showed that 3 or 4 treatments in the Crighton opener, as compared with the normal two treatments, yield an increase of only about three-quarters per cent. in the loss for each additional teatment. The extra treatment makes practically no difference to the behaviour in the spinning, as the ring-frame breakages are comparatively few whether the cotton has had 2, 3, or 4 treatments in the Crighton. There was no very great difference in the cleanliness of the yarn, and it was found most difficult to distinguish by eye between the various yarns which had been spun from any one cotton in any one count but which had been subjected to different numbers

of Crighton treatments; when a selection for cleanliness was made, it was not always the yarn which had received the greatest number of Crighton treatments which was selected as the cleanest. The difficulty of distinguishing the yarns according to the treatments which they have severally undergone in the spinning preparation serves to illustrate the close resemblance which the yarns bore to one another; that the distinction between them was not greater is not really surprising in view of the very small differences in the blow-room loss which resulted from the additional treatments in the Crighton opener. As regards the evenness of the yarns, it was found that for any one count all the different treatments yielded practically the same figure for evenness. The larger number of treatments appears to have resulted in a very slightly increased neppiness; however, no great importance can be attributed to the differences in neppiness caused by the various numbers of treatments, as these differences were quite small compared with those due to differences between the cottons. It would appear, according to the lea test, that a larger number of treatments yielded a slightly stronger yarn on the average; this is just the opposite of what would have been expected. However, the effect was really negligibly small except for the 20's counts, and in this case the differences were due almost entirely to the results for one only of the three cottons; moreover the results obtained for the single thread strength were by no means parallel to those obtained for the count-strength products. All the differences, however, were within the limits of experimental error, so that the only valid deduction from the results is that the effect on the yarn strength of the additional number of treatments is negligible.

The effect of additional scutching. When it was found that the repeated treatments in the Crighton opener made but little difference to the cleanliness of the spun yarns, an attempt was made in the case of one cotton—Punjab-American 289F—to determine whether repeated scutching might be more effective. From the results obtained, it was clear that repeated scutching also makes but little difference to the amount of foreign matter which is removed from the cotton. By the repeated scutching there was slightly greater loss in the blow-room and further loss in the card; even in total loss, however, the excess due to four scutchings (*i.e.*, one additional scutching) was only 0·6 per cent., and that due to five scutchings (*i.e.*, two additional scutchings) was 1·4 per cent. When the yarns were selected for cleanliness, it was found that the cleanest yarns were those from five scutchings and that the yarns from four scutchings were cleaner than those from three scutchings; as with the yarns subjected to different treatments in the Crighton opener, however, the differences in cleanliness were quite small, and even in the cleanest yarn there still remained much foreign matter, so that it compared unfavourably in cleanliness with yarn made from a clean-picked cotton.

The various yarns displayed no differences in evenness or neppiness; and although the ring-frame breakages showed considerable fluctuations for the different numbers of scutchings, it was clear that the numbers of breakages were compara-

tively small and the differences not significant. With regard to strength, it was found that the yarns which had had most scutching had the highest strength, whether judged by the count-strength product or by the single thread strength. It appears therefore that additional scutching, far from causing a loss of strength in the yarn by damaging the fibre, may actually lead to an increase of strength, presumably because some of the short and weak fibres are removed as waste in the card room, and possibly to some extent in the scutcher itself. It might be thought that this increased strength may be due to the better opening of the cotton leading to better drafting, and hence to greater regularity in the processes subsequent to scutching; that this can hardly be so, however, appears to be indicated first by the observations on the evenness of the yarns, and secondly by the values which were obtained for the single-thread irregularity.

To sum up, the results of the tests show that 3 or 4 treatments in the Crighton opener, as compared with the normal two treatments, yield an increase of only about three-quarters per cent. in the total waste for each additional treatment; otherwise the extra treatment makes practically no difference either to the behaviour in spinning, or to the appearance of the yarn—including its evenness and neppiness—or to the strength of the yarn. The effect of additional scutching, like that of the additional Crighton-opening, is comparatively insignificant.

These results, however, relate to small scale tests, and when cotton is being treated in bulk, somewhat different results might be experienced; in particular, the passage of the cotton through the opener is hardly likely to be perfectly uniform in bulk spinning, and it is quite possible that fluctuations in the flow might be inimical to the strength of the yarn. Damage might also occur if the beater shaft were run at a speed decidedly higher than that actually used, *viz.*, 750 r.p.m., although an increased speed would doubtless give a higher cleaning power also. Differences in settings and in the kind of grid used might also have some specific effect. All these points are briefly discussed in the original bulletin, in which the chief conclusions arrived at are :—

(1) that so long as the material passes uniformly through the blow-room, repeated opening or scutching effects a slight improvement in cleaning without detriment to the strength of the yarn; and

(2) that once cotton containing foreign matter is pressed into bale form, it may be very difficult if not impossible to remove the foreign matter completely—especially if it consists of fragments of seed-coat—so that the appearance and value of the yarn suffer accordingly.

Relation to cotton marketing. From the second conclusion some important corollaries may be drawn relating to cotton marketing. It is obviously important that cotton should be cleaned as far as possible at all stages prior to baling. This necessitates clean picking in the first instance, and possibly some cleaning of the

kapas before ginning and of the lint before pressing, besides the prevention of any contamination ; it also necessitates good ginning, for bad ginning may allow *kapas*, whole seeds, cut seeds, or fragments of seed-coat to become mingled with the lint and so eventually spoil the yarn in the manner indicated above. But if clean picking and good ginning are to be worth while, the difference in market value between high and low grade cotton must be higher than is indicated by the difference in blow-room loss alone. And seeing that baling the cotton in a cleaner state ensures a direct saving represented by the difference in blow-room loss, as well as indirect savings on the incidental charges of freight, insurance and storage—which are necessarily incurred on the extra foreign matter in the cotton—and finally, that from the cleaner cotton it is possible to spin a yarn which is cleaner and therefore able to command a higher price—it is clearly desirable that the cotton trade should offer every encouragement to the movement for securing cleaner cotton.

American cotton. It is interesting to note that in recent years—and particularly in 1926—much of the cotton crop in the United States of America has been marketed in a dirty condition, from which it would appear that the movement there is rather retrograde than progressive. There is no doubt that this is the result of the new methods which have been introduced in cotton picking, chiefly owing to the scarcity of human pickers. First there is "snapped" cotton which is obtained by plucking the entire opened bolls from the plants, the pickers wearing gloves to protect their hands against the cold and the roughness of the bolls. Next there is "sledded" cotton, so called because the cotton bolls—with much bark and stalk—are removed from the plant by a sled ; some hundreds of thousands of bales of sledded cotton were marketed from the 1926 crop. According to Mr. Arno S. Pearse, General Secretary of the International Federation of Master Cotton Spinners' and Manufacturers' Associations, sledding and snapping are really the first great evolution that has taken place in the cotton-growing industry since the invention of Eli Whitney's gin in 1793. Considerable progress also appears to have been made with mechanical cotton pickers, from which again the cotton is likely to be obtained in a dirtier condition than by hand-picking. This appearance on the market of large quantities of much dirtier cotton has had one very important consequence, *viz.*, the development of pre-ginning cleaning machinery. Huge strides have recently been made in this direction. Hence it appears possible that, in the future, emphasis may be laid on the cleaning of the cotton after picking and before ginning, rather than on clean picking itself. In India, as in America, therefore, the introduction of pre-ginning cleaning machinery may prove to be a solution of the problem of obtaining the cotton in a clean condition ready for pressing into bale form. However, the question still remains whether the use of pre-ginning cleaning machinery is likely to be more economical than giving a premium for clean picking and this is a question to which time alone can provide the answer.

III. The effect of the physical conditions in spinning.*

Any test, to be of value, should always give the same results for the same material. A spinning test is no exception to this general rule ; it should therefore always assign the same spinning value to any given cotton. But the results obtained in spinning depend not only on the cotton but also on many other factors, *viz.*, the machinery employed (and the speeds, settings, etc., at which it is run), the physical conditions—especially those of temperature and humidity—under which the various processes are carried out, and the human element. The situation is further complicated by the existence of some interaction between the various factors. However, one thing is clear—all the factors should be kept as constant as possible if the spinning test is to be satisfactory. Stringent precautions are adopted at the Technological Laboratory to see that the machinery factor does not change : and the operative staff has been carefully trained in the class of work required from them, and every effort made to reduce to as small dimensions as possible any disturbing effect due to the human factor ; it remains to consider the possible disturbing effects arising from changes in the physical conditions under which the tests are carried out. It is generally believed that, to get best results in cotton spinning, it is necessary to maintain both the temperature and the humidity above certain minimum values ; some go even further and state that not only should the temperature and humidity be kept fairly high, but they should not be allowed to fluctuate. Different values have been assigned by various authors to the minimum humidity which should prevail during spinning, but minima of 50 per cent., and even 60 to 70 per cent. relative humidity have been strongly supported, although the minimum has occasionally been put at 40 per cent. or even less. By means of the Carrier system of humidification installed in the spinning laboratory it would be possible to have standard conditions of temperature and humidity all the year round and so eliminate this factor ; but as no dehumidifying plant is available, it follows that the standard conditions would have to be such as could be maintained even in the monsoon months. These conditions are a temperature of 92°F. and a relative humidity of 70 per cent. Even with the ventilation which is afforded by the Carrier system, however, these conditions occasion much personal discomfort to the staff and must be regarded as comparatively unhealthy. And as, moreover, operatives are much more apt to make mistakes when they are working under such extreme conditions, it is evidently most desirable to avoid, if possible, the adoption of the standards mentioned as all the-year-round standards. Better and more trustworthy results may be expected when the operatives work under those conditions which ensure the maximum of comfort without vitiating the spinning tests. It was primarily for this reason that tests were undertaken at the Tech-

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* "The Effect of Temperature and Humidity on Cotton Spinning, with particular reference to conditions in Bombay", *Ind. Cen. Cotton Comm. Tech. Lab. Bull. No. 9, Tech. Ser. No. 4,* **August** 1927.

nological Laboratory to determine, if possible, what differences result from differences in the physical conditions under which the spinning tests are carried out. As, however, the subject is one of general interest to those engaged in cotton spinning, the opportunity was taken to review the whole question as to how the limit conditions of temperature and humidity normally experienced in the Bombay climate compare with the limits which are permissible without detriment to cotton spinning.

In this investigation the machinery factor was kept constant, and a study made of the effect of temperature and humidity on cotton spinning, using a number of different standard Indian cottons ; the object of using a number of cottons was to determine and so allow for the cotton factor alluded to above. Seven different cottons were therefore spun under three different sets of physical conditions of temperature and humidity. The cottons were : Dharwar 1 (Kumpta), Gadag 1 (Dharwar-American), Cambodia 295 (Co. 1), Nandyal 14 (Northerns), Hagari 25 (Westerns), Karunganni, and Memphis (American). The spinning conditions were (1) *medium-dry*, *i.e.*, conditions obtained when the outside relative humidity is at its lowest (30 to 50 per cent.) ; (2) *normal*, *i.e.*, conditions in which the temperature is about but not below 80°F. and the relative humidity is about 65 per cent. but never below 60 per cent. ; and (3) *monsoon*, *i.e.*, conditions in which the temperature is 90°F. and the relative humidity is about 70 per cent. These three sets of physical conditions may be taken as covering the range of conditions experienced in Bombay ; in up-country districts much drier conditions often prevail—*viz.*, temperatures above 100°F. accompanied by relative humidities below 30 per cent.,—so that the conclusions drawn from the present investigation cannot be applied directly to such dry conditions.

Each of the seven cottons was spun in duplicate into three different types of yarn under each set of physical conditions. Observations were made of the effects of the several conditions on (1) comfort of the operative staff in working ; (2) workability of the material ; and (3) appearance and strength of the yarn. From this it will be seen that attention was paid to just those points which matter from the practical point of view. The following observations were made during these tests :

Comfort. It was found that the operatives were more comfortable and preferred to work under the normal conditions rather than either of the extremes.

Workability of material. As to workability of the material, observation showed that under the medium-dry conditions web-shedding in the card was less than normal, as was also the total waste in this machine ; but throughout the processes the material was dry and fuzzy, giving very little fly, but occasionally giving trouble in the drawing frames. Under the monsoon conditions web-shedding and total waste in the card were rather greater than normal throughout the processes, however, the material ran very well, being soft, silky and free from liveliness, but depositing a good deal of leaf, nep, etc., on the ring rails.

The differences in the waste made by the different cottons are summarized in the following table :—

Conditions	Blow Room Loss (%)	Card Room Loss (%)	Relative Humidity (%)
Medium-dry	6·9	5·8	46
Normal	6·7	6·6	66
Monsoon	6·9	7·2	72

From this table it can be seen that the differences in the blow-room loss under the different conditions are insignificant; the card-room losses, however, are decidedly greater under the normal conditions than under the medium-dry, and greatest of all under the monsoon conditions. It may be remarked that this order of differences of card-room loss invariably occurred for each individual cotton. A small part of it may be attributed to the different humidity conditions in the spinning room in which the carding was done, but the greater part represents a real loss of cotton, presumably of the shorter fibre.

The number of ring frame breakages is taken as an index of behaviour of the material during the actual spinning, and the following mean results were obtained for the six cottons which were spun into the three undermentioned counts :

Yarn breakages per 100 spindles per hour.

Conditions	20's	30's	40's
Medium-dry	5	4	4
Normal	5	4	5
Monsoon	5	4	4

This summary table shows that the cottons spun well under all three sets of conditions.

Appearance of yarn. The yarn spun under the medium-dry conditions was oozy, and very lively and full of crimp, as reeled soon after being doffed from the ring frame ; the yarn spun under normal conditions did not suffer from these drawbacks to anything like the same extent ; and the yarn spun under monsoon conditions was in general very smooth and free from crimpiness. That the yarns were unaffected by the different conditions, so far as their evenness and neppiness are

concerned, is clear from the following table showing the mean results for all cottons except Karunganni (which was not spun into 40's counts) :—

Conditions	Evenness class			Neps per yard		
	20's	30's	40's	20's	30's	40's
Medium-dry	2·5	4	5	1·3	1·3	1·6
Normal	2·5	4	5	1·6	1·7	2·0
Monsoon	2·5	4	5·5	1·7	1·9	2·0

This table shows that although the evenness and to some extent the neppiness are much affected by the counts of yarn spun, yet the effect of altering the conditions of spinning is insignificant. The same result was obtained for each of the individual cottons, which differed considerably among themselves in these two properties.

Strength of yarn. An analysis of the relative spinning test results under the different conditions showed that, taking all counts together, in one case the medium-dry-spun yarn is stronger than the normal-spun yarn ; in 12 cases the normal-spun yarn is stronger than the medium-dry-spun yarn ; and in 7 cases the differences are inappreciable. In 5 cases the monsoon-spun yarn is stronger than the normal-spun yarn ; in 8 cases the normal-spun yarn is stronger than the monsoon-spun yarn ; and in 8 cases the differences are inappreciable.

The following table shows the average values obtained for the count-strength products and the single-thread strengths under the different conditions, for the six cottons spun into 20's, 30's and 40's counts ; the values given below are the average values for all the cottons spun into a particular count :

Conditions	Count-Strength Product			Single-Thread Strength (oz.)			Testing Room R. H.%		
	20's	30's	40's	20's	30's	40's	20's	30's	40's
Medium-dry .	1,781	1,563	1,296	12·3	7·6	5·4	58	59	56
Normal .	1,827	1,610	1,369	12·4	8·1	5·8	63	67	67
Monsoon .	1,835	1,606	1,371	12·7	8·0	5·6	64	63	64

Each strength figure in the table above is the average of 600 tests for lea strength and 1,200 tests for single thread strength. Taking all counts together, we get the following average figures :—

Conditions	Count-Strength Product	Single-Thread Strength (oz.)	Testing Room R. H. (%)
Medium-dry	1,547	8·4	58
Normal	1,602	8·8	66
Monsoon	1,604	8·8	64

Each figure in this table represents the average of 1,800 tests for lea strength, and 3,600 tests for single thread strength. It will be observed that on the average the differences between the strengths of yarn produced under the different conditions are very small; as between the normal and monsoon conditions, the differences are indeed negligible. From the summarized results, however, it appears that the normal-spun and monsoon-spun yarns are equally strong, and that they are slightly stronger than the medium-dry-spun yarns, the differences in the count-strength products being between 3 and 4 per cent., and in the single thread strengths about 5 per cent. The slight superiority of the normal-spun and monsoon-spun yarns is no doubt partly due to their being tested at a slightly higher humidity, as will appear from column 4 of the table above; but this still leaves about half the difference in strength unaccounted for; the remainder may probably be traced to the greater card-loss—presumably of shorter fibre—sustained by the cotton of the normal-spun and monsoon-spun yarns. The difference may also be partly due to the slightly greater trouble occasionally experienced with the cotton in the drawing frames under the medium-dry conditions. The most important point to observe, however, is that the total differences in strength between the yarns spun under the different conditions are very small—so small indeed, that their presence might have been masked by the inevitable sampling errors if the tests had been confined to one cotton, so that from a practical point of view the differences referred to can hardly be regarded as possessing any great significance.

The climate of Bombay. A section of the bulletin deals with the temperature and humidity conditions of Bombay in relation to cotton spinning. Tables are given from which can be ascertained the normal temperature and the normal humidity experienced in Bombay for each hour of the day for every day of the year; an analysis is also given of the frequency of occurrence of conditions of low humidity during the comparatively dry period—December, January and February. From a consideration of these conditions, and of the spinning test results obtained under the various conditions of temperature and humidity, it is concluded that the climate

of Bombay is a most suitable one for the processing of the material in cotton spinning.

As already pointed out, however, the human factor has also to be considered as well as the processing of the material. And although the comparatively hot and humid conditions of Bombay may make it easy to secure satisfactory conditions for the processing of the material inside the mill, and may indeed feel comfortable to the worker, it by no means follows that they are the most desirable conditions for the worker to live in, day by day and month by month. The temperature to which the Indian operative is subject outside the mill often does not differ greatly from that inside the mill. The state of affairs is quite different in Europe, where the mill operatives are subject to daily and seasonal ups-and-downs in temperature which have a decidedly bracing effect; thus the enervating effect of the atmosphere inside European mills is partly counteracted by the tonic effect of the changes in the climatic conditions which the worker experiences when he leaves the mill. This is no doubt one reason why the European mill operative works with greater intensity than his Indian *confrère*. Hence it would appear that the climatic advantage which Bombay enjoys in connection with the processing of the material is offset by the climatic disadvantage to which the human factor is subject.

The effect on production. It may be observed that the chief economic consideration in cotton spinning as in any other industrial process is the cost of production in relation to the selling price. When, as in the case of cotton yarn and cloth, the manufactured article has to compete in the world markets, the effect of climate on production in the different producing centres is a most important one. It is largely because of climatic effects on the human element that Indian mills have to employ far larger numbers of operatives than are necessary in a European mill. The production of a spinning mill, however, is entirely a matter of ensuring that the ring spindles are ontinuously spinning yarn. Loss of production is due to some of the spindles not producing,* and may arise from the following common causes: (1) yarn breakages, so long as they remain unrepaired; (2) the necessity for doffing full bobbins and replacing them by bare bobbins; (3) spindles being stopped while spinning bands are being replaced on them; and (4) the shortage of full roving bobbins to fill the creels of the spinning machines.

We may now examine how these causes of a falling off in the production are likely to be affected by differences in the physical conditions of spinning. From what has already been said, it will be clear that so far as the processing itself is concerned there is no reason to apprehend a loss of production from any of these causes. But the human factor is another matter; if the conditions are not satisfactory it

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* In any comparative production test, it is of course most important to see that in each case the product is in the same "condition," *i.e.*, has the same moisture content: if yarn is spun under dry and humid conditions respectively without any change in the cotton mixing or the machinery, and is weighed as tpun, the extra moisture present in the more humid yarn must be allowed for—it must not be reckoned as a real increase in the production.

is conceivable that the operatives may take more time in repairing breakages, in doffing the full bobbins, and in replacing spindle bands. Hence very cold or very hot conditions in a mill, or the extreme conditions here referred to as the monsoon conditions, especially if coupled with bad ventilation or little air movement, may possibly lead to a reduced production. The Laboratory tests were not of a nature to indicate whether any loss of production would be experienced in this way, and if so, what its magnitude would be, as it would depend upon the particular conditions existing in each mill—the operatives, the management, the machinery, the cotton mixing and the counts spun from it—and would accordingly have to be determined for each mill separately.

Conclusions. The following are the chief conclusions drawn from these tests :—

(1) *Comfort.* For the comfort of the operative staff the normal conditions about (but not below) 80°F. and about (but not below) 60 per cent. R. H. are more satisfactory than either of the extreme conditions.

(2) *Workability.* For workability of the material in processing, the dry conditions are undesirable as they lead to fuzzy material which occasionally gives some trouble. Normal conditions are satisfactory throughout. Monsoon conditions give rise to excessive web shedding and rather more waste in the card, but otherwise cause no trouble.

(3) *Appearance of yarn.* Yarn spun under medium-dry conditions is oozy and very crimpy ; yarn spun under normal conditions is less oozy and less crimpy than the yarn spun under medium-dry conditions ; yarn spun under monsoon conditions is very smooth and free from crimpiness. These differences practically disappear when the yarn is conditioned.

(4) *Strength.* Within the limits of temperature and humidity within which these tests were carried out, it is impossible to lay down any hard and fast rule as to which conditions (medium-dry, normal, or monsoon) will give rise to the strongest yarns, the differences for the most part being inappreciable, although there appears to be a tendency for the medium-dry conditions to lead to slightly weaker yarns.

(5) *General.* The processing of the material in cotton spinning and the quality of the spun yarn are not seriously affected by the spinning processes being carried out at relative humidities as low as 40 per cent. ; but taking all things together, the normal conditions are probably best for carrying out cotton spinning tests.

(6) *Bombay conditions.* Bombay conditions are practically ideal for the processing of the material in cotton spinning.

(*To be continued*).

MANURING OF PADDY IN LOWER BURMA.

BY

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On the $9\frac{1}{2}$ million acres of swamp paddy land in Lower Burma where almost the whole of the Burma rice of commerce is produced, the paddy crop has hitherto been grown practically without manure. There is an impression abroad that this land receives an annual coating of river silt which enriches the soil and maintains its fertility. But so far as the main paddy is concerned, this is not so: and the land which does receive this coating of silt, with the exception of some parts of the lower Delta, is generally in such a precarious position, liable to severe damage by floods, that paddy growing there is a very speculative business and may be left out of consideration in the present paper entirely. The main part of the paddy area receives no annual coating of silt, but is on such a level that, while by means of small field embankments it can hold enough rain water to mature a crop with a growing period of 150 to 200 days, it is high enough to be comparatively safe from the flood waters of the Burma rivers during the monsoon.

The comparatively high prices ruling for paddy since the War have encouraged the extension of cultivation into the low lying and more precarious tracts which do receive silt, and it is chiefly owing to this fact that so much has been heard in the past few years of the increasing damage done by floods to the paddy crop: for these low lying areas on the margin of cultivation, and more or less recently brought under the plough, have suffered most.

Permanent level of fertility reached.

The system followed, of continuous annual cropping with paddy, is exhausting when practically nothing in the way of manure is returned to the soil; but most of the land has already lost its virgin fertility and has been reduced to a level of productiveness which now appears to be fairly constant—a level at which the plant food removed by the annual rice crop is made good by the natural break down of the soil. The only reliable statistics available do not show that there has been any progressive decline in fertility within recent times; and this is supported by Settlement and other reports going back farther than 1913-14, from which year comparable records of acreage yields are available. Taking the Hanthawaddy District Settlement Reports as an example, the Reports from 1872 to 1910 show

that in the areas dealt with, there has been no decline in fertility during this time. The actual figures given, show yields per acre well above the average now accepted for the country as a whole, and we are probably safe therefore in assuming that under the present system of cultivation a general average yield of about 1,500 lb. per acre, apart from annual fluctuations, may be expected to continue in Lower Burma for some considerable time.

Under the circumstances, this yield may be considered fairly good and compares not unfavourably with that of some other tropical rice growing countries. The following table compiled from figures extracted from the International Year-Book of Agricultural Statistics shows the relation between the principal rice growing countries in 1926. The figures must be regarded as a rough indication only, since methods of recording yields vary in different countries, and China, one of the largest rice growing countries, records no figures at all. Thus as an example, the acreage yield in India as a whole is based on the sown area, while that for Burma is on the matured area only.

PRINCIPAL RICE GROWING COUNTRIES.

Country	Acreage of rice	Yield per acre
		lb.
India	79,134,000	1,281
China	..	..
Indo-China	12,795,000	1,041
Java	8,356,000	1,378
Japan	7,738,000	2,875
Siam	7,157,000	1,680
Phillipines	4,252,000	1,014
Korea	3,885,000	1,565
French Guinea	2,038,000	890
Formosa	1,400,000	1,761
Madagascar	1,372,000	960
Brazil	1,323,000	1,130
U. S. America	1,014,000	2,252
Ceylon	829,000	676
British Malaya	664,000	1,006
* Soviet Russia	583,000	1,050
Sierra Leone	400,000	1,503
Italy	365,000	4,062
Egypt	191,200	2,847
Senegal	123,300	890
Spain	121,000	5,800
Mexico	118,400	1,360

* Pre-War—1909-1913.

The yields in Spain, Italy and Japan are outstanding, and have been so for many years, due to the intensive methods adopted there: but it is worth while noting that until 1916 the yield in America was approximately the same as for

Burma, and the higher figure now shown is a comparatively recent achievement. This increased yield has been brought about principally by the more extended use of fertilisers; and although a similar increase could be brought about in Burma by the same means, this could not in the past be done at a profit for reasons which will be adduced later.

NEED FOR MANURING.

The need for manuring of paddy land in Lower Burma has been one of the subjects under investigation at the Hmawbi Experimental Station for a number of years, and among other experiments a series of plots treated with different manures was laid down in 1913 designed to ascertain what manurial constituents were deficient in these soils, and to what manurial treatment they would probably respond best. This experiment was continued for 10 years, the individual plots being manured as shown below for 5 consecutive years, and the controls left untreated. Manuring was then discontinued and all plots were observed for a further period of 5 years to record the residual effect of the different manures employed. The results have been published in the annual reports of the Hmawbi Station, but I have condensed them here into a single table which is given below.

No.	Treatment (per acre).	5 years manure. Per cent increase over average of controls	5 years residual effect. Per cent. increase over average of controls
(a)	(b)	(c)	(d)
1	Cattle manure at 30 lb. nitrogen	+37·5	+21·8
2	Cattle manure at 50 lb. nitrogen	+52·3	+34·5
3	Cattle manure at 70 lb. nitrogen	+68·7	+37·8
4	Cotton cake at 50 lb. nitrogen	+54·8	+29·2
5	Cattle manure at 30 lb. nitrogen, Superphosphate at 30 lb. P_2O_5, Sulphate of potash at 30 lb. K_2O.	+53·0	+54·0
6	Cattle manure at 30 lb. nitrogen, Superphosphate at 20 lb. P_2O_5.	+43·5	+27·6
7	Cattle manure at 30 lb. nitrogen, Bone-meal at 20 lb. P_2O_5.	+51·0	+31·8
8	Bone-meal at 20 lb. P_2O_5	+26·5	+9·5
9	Superphosphate at 20 lb. P_2O_5	+35·3	+15·3
10	Sulphate of potash at 20 lb. K_2O.	+5·0	—6·6
11	Sodium nitrate at 30 lb. nitrogen	—17·0	—35·5
12	Sodium nitrate at 30 lb. nitrogen. (Applied as top dressing).	+5·0	—25·0
13	Nitrolim at 30 lb. nitrogen	+11·0	+64·2
14	Ammonium sulphate at 30 lb. nitrogen	+32·5	—25·5
15	Lime at 2,000 lb.	+24·0	+1·9
16	Ammonium sulphate at 30 lb. nitrogen, Superphosphate at 20 lb. P_2O_5, Sulphate of potash at 20 lb. K_2O.	+33·5	+17·5

Among other information provided by this table, the most important facts are the indications given that the chief requirements of paddy on these soils are nitrogen in the form of ammonia, and phosphate : that potash is not shown to be a definite limiting factor : and that nitrogen in the form of nitrate is distinctly harmful. The deficiency in nitrogen and phosphate shown, is confirmed by the chemical analyses of these soils which are also published in the Station Reports, and subsequent experiments have borne out the correctness of the conclusions drawn. The Lower Burma soils differ from the Upper Burma soils in being distinctly acid, and respond to dressings of lime although in no very great degree : and experiments with lime have shown that while it is beneficial to the soil and increases the crop, the cost renders its use uneconomic.

Indigenous manures available.

The more or less readily obtainable indigenous manures able to supply the deficiencies indicated include cattle dung, bats' guano, fish waste, bone-meal, rice bran, cotton cake, green manure crops, etc., but the quantities of each are quite inadequate for the purpose of bringing about any marked increase in fertility. Cattle dung is by far the most important and the quality and amount of this available for paddy land may well be considered first.

In the system of cultivation followed, one pair of bullocks is able to work from 8 to 12 acres, and as there is practically no land other than paddy land worked by bullocks, an average of one pair of bullocks to every 10 acres is a reasonable figure to assume for the ratio of livestock to cultivated area. Cattle are only bred locally to a negligible extent owing to the unsuitable swampy conditions, and nearly all the working bullocks are imported from the dry zone of Upper Burma. This being so, the cultivator seldom keeps more bullocks than are strictly necessary to cultivate his land, and he has no young stock to augment his supply of cattle dung. Other cattle there are, kept on the uplands by Indian cow keepers for milk purposes, but these contribute practically no manure to the paddy land. The ratio of one pair of bullock to 10 acres of land is borne out by the figures of livestock and the cultivated area for the two great paddy growing Divisions in Lower Burma. The Pegu and Irrawaddy Divisions comprise between them 7,342,174 acres of cultivated land including gardens, which constitute only about 6 per cent. of the whole : the livestock comprising bulls, bullocks, cows and young stock, and including all classes of buffaloes, amounts to 1,490,134 animals, or 745,067 pairs, which is near enough 1 : 10 for our purpose.

The amount of dung which a single bullock will contribute to the manure pit in the course of a year, according to records kept at the Hmawbi Station, is about 3 tons, or approximately 6 tons for a pair. If carefully conserved, this amount would be available each year for 10 acres of paddy land : but under village conditions the need for careful conservation is not appreciated, and the wastage is so great that not more than half this quantity ultimately finds its way to the land.

In fact so little is the value of cattle dung appreciated in some of the more fertile tracts, that I have seen a cultivator throw it into a near-by creek to avoid the trouble of storing and carting it on to his land.

The more ordinary way of using the available cattle manure is to collect what has been loosely stored in the open for the past year and spread it on the nurseries which constitute a tenth of the holding : the main area is not manured at all. The manure so applied, in addition to being deficient in quantity, is lacking in quality : concentrates are only fed to the cattle on a small scale, and when the manure has been stored in the open through part of the rains it is very poor stuff indeed, as analyses show.

There is a good deal of scope for improvement in the methods of conserving and applying this best of all manures, and efforts towards bringing this about are being made by the Agricultural Department : but even when the best has been done, the fact remains that there is not enough cattle manure to go round, and a dressing which at best averages about 3 tons for 10 acres, can hardly be considered sufficient to maintain the fertility of the land, far less to improve it.

Of the other manures such as bats' guano, fish waste, bone-meal, rice bran, cotton cake, etc., these are either strictly limited in quantity like the first three, or fetch higher prices for other uses outside general agriculture than they are worth as manure. Even the purely manurial substances like bats' guano and fish guano sell for much higher prices to gardeners and concerns growing valuable money crops than a crop of low money value per acre like paddy can afford to pay. The use of these expensive manures on paddy although it increases the outturn per acre considerably, results in a heavy monetary loss, as experiments at the Hmawbi Station clearly show. Bone-meal is on the border line and just manages to pay its way.

The growing of green manure crops constitutes a well recognised method of maintaining and improving soil fertility, but on the old paddy land these cannot be grown with any reasonable prospect of success. When the rains finish in early November, the soil dries up very quickly and assumes a cement like hardness in which no green crops will grow : even seeds broadcasted among the ripening paddy crop fail to establish themselves. Most of the known green manure crops and the different methods of growing them have been tried under these conditions, but have failed. The hard condition of the ground associated with the long rainless spell from November till May renders growth difficult, but on some of the retentive soils of the middle zone to the north of the main paddy area I have seen a green crop of sunn hemp grow very well indeed.

These are the main sources of indigenous manure. Night soil is not included, for the people of the country will not touch it : and the attainment of a high standard of permanent and increasing fertility by this means, similar to that existing in China and Japan as described in King's 'Farmers of Forty Centuries,' appears to be outside the bounds of possibility.

Synthetic farm-yard manure appeared an attractive proposition for Burma, but it is expensive to make, and experiments with it at Hmawbi since 1923 have been disappointing so far as profits are concerned. The prospect of its use has not been abandoned, however, and experiments with this form of manure are being continued.

Artificial fertilizers.

This brings us to the use of imported fertilizers to augment the scanty supplies of indigenous organic manures, and the reasons why these have not been more strongly advocated for paddy in the past.

To supply the important constituents of ammoniacal nitrogen and phosphoric acid, the manures available hitherto have been sulphate of ammonia and superphosphate, and these have proved entirely suitable for the swampy conditions under which paddy is grown. But it has already been mentioned that a crop of low money value per acre like paddy cannot give an economic return for expensive manures. As I shall show later, imported sulphate of ammonia and superphosphate are cheaper than the indigenous manures already dealt with, and the question of whether it was economic or not to use these manures has depended upon the relative prices of the manure and the paddy, both of which have fluctuated considerably in the past.

The prices of sulphate of ammonia and superphosphate at Rangoon before the War, at the end of the War, and at the present time, are as follows :—

Year	Sulphate of ammonia per ton	Superphosphate (18-20) per ton
	Rs.	Rs.
1914	240	75
1919	488	150
1928	170	75

For 10 years before the War, the threshing floor price of paddy in the districts close to Rangoon fluctuated from Rs. 96 per 100 baskets (approximately 5,000 lb.) to Rs. 152 per 100 baskets. The price in 1914 was Rs. 125, and the average for the 10 years period prior to the War was Rs. 124. Since 1920 the price has fluctuated between Rs. 145 and Rs. 196 with an average of Rs. 176. In the present year the threshing floor price was Rs. 170, but contrary to custom has fallen since to Rs. 160 at the beginning of the rains.

Taking the general average crop as 1,500 lb., or 30 baskets per acre, an application of 1 cwt. of sulphate of ammonia *plus* 1 cwt. of superphosphate per acre can be expected to increase the crop by approximately 30 per cent. The actual increase to be expected varies with soil and other conditions, but that this figure is not an overestimate will be shown by the results of a recent experiment to be quoted later.

Taking the situation as it was in 1914, let us see what the monetary results of such an application to such a crop would have been.

Adding Rs. 10 per ton to the cost of sulphate of ammonia and to that of superphosphate to get the manure from Rangoon on to the cultivator's holding, one cwt. of the former would cost Rs. 12-8 and of the latter Rs. 4-4, a total of Rs. 16-12. A 30 basket crop at Rs. 125 per hundred baskets would be worth Rs. 37-8. An increase of 30 per cent. on this would be Rs. 11-4 ; and the difference between Rs. 16-12, the cost of the manure, and Rs. 11-4, the resulting increase in the crop, would be a loss of Rs. 5-8 per acre.

In 1928 the corresponding figure would be : cost of manure Rs. 13-4 ; value of crop Rs. 51 ; value of 30 per cent. increase, Rs. 15-5 ; result, gain of Rs. 2-1 per acre.

These figures are shown more concisely in the following form :—

— —	Paddy price per 100 baskets	Value of crop of 30 baskets per acre	Value of 30 per cent increase	Cost of manure per acre	Difference
	Rs.	Rs.	Rs.	Rs.	Rs.
1914	125	37·5	11·25	16·75	Loss 5·50
1928	170	51·0	15·30	13·25	Gain 2·05

NEW ARTIFICIAL FERTILIZERS.

This shows clearly the change which has been brought about since before the War, partly by the drop in the price of artificial manures and partly by the rise in the price of paddy. But a circumstance has arisen which is of greater importance. This is the advent of the new manures combining ammoniacal nitrogen and phosphate in one, produced at a cheap rate by methods evolved as a result of the work done on high explosives during the War. Two of these are available now in India and one of them has been tried over the past three years on paddy land at Hmawbi, and in the surrounding districts. With another now under trial, calculating the cost per acre on exactly the same basis as in the previous table,

the cost of the same quantities of nitrogen and phosphate to produce the same effect would be Rs. 11-2 instead of Rs. 13-4, and the price of paddy would have to fall below Rs. 124 per 100 baskets before the balance of profit and loss were tipped in the wrong direction. These new manures also possess the added advantage of being single chemical compounds which require no mixing; and owing to their concentration, the transportation charges are cut in half.

Experimental results.

The first of these new manures to come to hand for trial in 1924 was Ammo-Phos which was obtained from New York in two grades, 20-20, and 13-48. This gave promising results, and an experiment was put down last year to determine the optimum dressing per acre. The quantities used were 50,100,200, and 300 lb. per acre, and the plots for each were laid out in a continuous series, each treatment being replicated 6 times. The size of each individual plot was approximately 1-41 of an acre. The response to the manure was remarkable, and although the season was a good one, and the appearance of the plots during the growing season bore out the final weighing results, the percentage increases of from 47·7 per cent. to 118·6 per cent. are higher than can be normally expected. Taking the cost per ton of Ammo-Phos *plus* freight at Rs. 230 for the 20-20 grade, and Rs. 255 for the 13-48 grade; paddy at Rs. 170 per 5,000 lb.; and allowing nothing at all for the increased straw which has no value in Burma, the results of the experiments with the 20-20 grade and 13-48 respectively were as follows:—

Ammo-Phos. 20/20 grade.
Fields Nos. 75 and 76. Size of plots—0·024 acre.
Variety of paddy—C19-26. Replicated 6 times: 32 plots.

No.	Nature of treatment per acre	Yield per acre		Increase per acre		Value of increase per acre	Cost of treatment per acre	Profit per acre due to manure	Per cent. increase in grain per acre
		Grain	Straw	Grain	Straw				
	1	2	3	4	5	6	7	8	9
		lbs.	lbs.	lbs.	lbs.	Rs. A.	Rs. A.	Rs. A.	
1	Control . .	1,250	3,292	..	..	..	..	..	—
2	50 lb.	1,846	4,158	596	866	20 4	5 2	15 2	47·7
3	100 lb. . .	2,096	5,267	846	1,975	28 12	10 4	18 8	67·7
4	200 lb. . .	2,542	6,504	1,292	3,212	43 15	20 8	23 7	103·4
5	300 lb. . .	2,733	7,250	1,483	3,958	50 7	30 12	19 11	118·6

Standard error . . . . 4·6 per cent.

Ammo-Phos. 13/48 grade.
Fields Nos. 51 and 52. Size of plots—0·024 acre.
Variety of paddy—C19-26. Replicated 6 times: 32 plots.

No	Nature of treatment per acre	Yield per acre		Increase per acre		Value of increase per acre	Cost of treatment per acre	Profit per acre due to manure	Per cent. increase in grain per acre
		Grain	Straw	Grain	Straw				
	1	2	3	4	5	6	7	8	9
		lb.	lb.	lb.	lb.	Rs. A.	Rs. A.	Rs. A.	
1	Control . .	1,533	3,846	..	..	..	..	..	..
2	50 lb. . .	1,971	4,358	438	512	14 14	5 11	9 3	28·6
3	100 lb. . .	2,017	5,200	484	1,356	16 7	11 6	5 1	31·9
4	200 lb. . .	2,575	6,071	1,042	2,225	35 8	22 12	12 12	67·9
5	300 lb. . .	2,650	5,659	1,117	1,813	38 0	34 2	3 14	72·9

Standard error 3·7 per cent.

These are exceedingly promising results and raise several points of interest which there is no space to discuss here; but one thing is made clear, and that is, that profitable manuring of paddy with artificial fertilizers available in quantity is now within the scope of possibility. After discounting the admittedly high increases, which are nevertheless given as they weighed out, it must be remembered that the profits shown are for one year only, and previous experiments at Hmawbi have shown that the effect of this manure lasts for two years, the increase in the second year being from one-third to two-thirds those in the year of application. The second year, or residual effect of the 13/48 grade is higher than that of the 20/20 grade, which is to be expected from the higher phosphate content of the former; but the quick returns obtained with the 20/20 grade in the first year are all important where money for expenditure on manures of this sort may have to be borrowed at excessively high rates of interest. Incidentally, interest charges have not been included in the above tables, but the profits shown allow for a fair addition of this kind.

In both cases the optimum rate of application is 200 lb. so far as profit per acre is concerned, but the outlay involved in such a dressing is hardly likely to commend itself to such landowners and cultivators who may be induced to take up these manures for some time to come. Applications of 50 and 100 lb. are quite satisfactory however and these should be good enough to begin with. The time of application is important. The best time is when the fields have been more or less drained off before transplanting: applied later when the fields are full of water the manure is wasted.

NITROGEN : PHOSPHORIC ACID RATIO.

Before leaving these two grades of manure, I am tempted to quote another Hmawbi experiment showing the optimum ratio of nitrogen to phosphoric acid for the paddy soils being dealt with. The experiment was a pot experiment and the results obtained indicate that the best ratio lies somewhere between 1 : 1 and 1 : 3 of N : P_2O_5 with a strong assumption that it is about 1 : 2.

Optimum Nitrogen/P_2O_5 ratio.
Variety of paddy C15-10. Replicated 10 times : 60 pots.

No.	Treatment N : P_2O_5 ; ratio	Tillering	OUTTURN			Grain Straw weight ratio	REMARKS
			Grain	Chaff	Straw		
1	2	3	4	5	6	7	8
			gm.	gm.	gm.		
1	Control . .	8·6	29—58	0—98	45—47	1:1·54	
2	1:½ . .	10·0	25 23	1·31	55—50	1:2·20	
3	1:1 . .	9·5	30—17	1·00	52 -10	1:1·69	Standard error ± 1·6 or 5·3 per cent.
4	1:2 . .	8·6	34—68	0·45	50—99	1:1·47	
5	1:3 . .	8·7	32—69	0·63	56·87	1:1·73	
6	1:4 . .	9·2	28·33	0·75	58 98	1:2·07	

These figures, though fairly regular and indicative of whereabout the ratio lies, are not accepted as final, and the experiment is being repeated this year on a field scale.

Another experiment on a field scale showing the ineffectiveness of potash when added to nitrogen and phosphate manures on these soils might be quoted, but the full experiment will be found in the printed report of the Hmawbi Station, and it will suffice here to say that at present this manure does not pay its way.

COMPARATIVE COSTS OF COMMON MANURES.

While on the subject of these manures and their relative costs, it is of interest to note the unit values of those which have been referred to in this paper, and taking present prices, I have tabulated these below. With the exception of the slow acting bone-meal it will be seen that indigenous manures are dearer per manurial unit than the new artificial fertilizers. Of course, organic manures have an additional value

of their own, but here they are limited in quantity, and any increase in demand is followed by sharp rises in price as has been noticed in the case of bats' guano.

No.	Manure	Place	Price per ton Rs.	Analyses			Unit Values, Rupees		
				N	P_2O_5	K_2O	N	P_2O_5	K_2O
1	Ammonium sulphate	Rangoon	170	20·6	..	..	8·25	..	..
2	Superphosphate 18/20	Do.	75	..	19	..	..	4	..
3	Sulphate of potash	Do.	205	..	..	50	..	..	4·1
4	Ammo-Phos. 20/20	Do.	220	16·48	20	..	8·12	4·08	..
5	Ammo-Phos. 13/48	Do.	245	10·70	48	..	7·21	3·50	..
6	Bats' guano	Kyaukse	55	5·03	1·86	0·83	8·67	4·20	4·31
7	Bone-meal	Rangoon	85	2·04	32·78	..	4·82	2·31	..
8	Fish manure	Do.	150	7·71	2·95	0·65	15·8	7·7	7·88
9	Cotton seed meal	Do.	82·5	5·90	2·70	1·45	10·40	5·10	5·3
10	Cotton seed cake	Do.	88·4	6·71	2·34	1·33	10·2	4·95	5·15
11	Diammonphos 20/53	Do.	307	20·60	52·50	..	6·66	3·23	..
12	Leunaphos 20/20	Do.	213·6	20·20	20·30	..	7·10	3·45	..

The cheapest manure of suitable composition in this list is No. 12. There have been alterations in the prices of these new manures recently, but there appears to be a reasonable prospect of their settling at lower level later. Import duty of 15 per cent. *ad valorem* has recently been imposed on these ammonium phosphates, but this is not likely to continue and has not been taken into consideration above.

Other manures such as urea and cyanamide, etc., have not been mentioned here although experiments have also been carried out with them. Unit for unit, however, they are not so effective as the fertilisers dealt with, and more extended experiments have not been included in the annual programmes.

Conclusion.

This then is the situation we have arrived at. The cultivation of rice in Burma on the present enormous scale is of comparatively recent origin : from 1866 until the present year the paddy area has grown from 1,760,271 to 11,826,700 acres ; and in this time the original virgin fertility of the soil has been largely exhausted. To maintain the standard of fertility at its present level, the indigenous manures are barely sufficient, and to increase it they are quite inadequate. To achieve the desirable end of increasing the production per acre, there are several lines of approach : improved implements and cultivation can do a little, and the use of improved and higher yielding strains of paddy can also do a little : but the total improvement which can be attained by these means is small, and a really significant increase can only be brought about by better feeding of the crop.

Before the War and for some time after, the relation between the price of paddy and the price of the artificial fertilisers which were suitable for this purpose was such that manuring of this sort could not be undertaken at a profit. Since the War, the position has changed : the price of paddy has risen and the cost of the old manures has fallen to its previous level. Furthermore, a new class of manures has become available, peculiarly adapted to the needs of Lower Burma soils, and considerably cheaper than the Sulphate of Ammonia and Superphosphate which have been the standard manures in the past. The consequence is that artificial manuring has now become a paying proposition for paddy, as it has been for more valuable crops in the past, and the Agricultural Department is now for the first time in a position to recommend these manures to the cultivators, with the assurance that under suitable conditions a reasonably good profit will result. It is most decidedly not intended that these manures should displace cattle manure which is still the best of all, but that they should be used to supplement what little supplies of this are available under the rather abnormal system of agriculture which obtains in Lower Burma. Thirty-six district trials were carried out with Ammo-Phos in the Southern Circle last year, and although the conditions for carrying out experiments in the districts are not such as to yield data comparable in accuracy with that obtainable on a fully equipped Experimental Station, the results showed that the response to the manure was sufficient to justify the belief that the Hmawbi experience is likely to be repeated further afield. About one hundred field demonstrations are therefore being put down on cultivators' holdings this year, and as experience accumulates, this work will be extended.

The question may be asked whether the Burmese cultivator will take to these new manures : I think he will. The process will be a slow one, but there are indications that a beginning will not be difficult to make. Bone-meal and rice bran are beginning to be bought for manurial purposes even now, and I know of one village which bought 20 tons of bone meal last year for its paddy land. These last mentioned substances are slow acting and return a very meagre profit, so that when new and more profitable manures are put at his disposal, the cultivator is likely to respond. It is even just possible that experience of such manures may have an indirect effect of creating a keener appreciation of the manurial substances already at his hand. The chief difficulties lie in his chronic indebtedness and the excessive rates of interest he has to pay for any money he may have to borrow for additional expenditure, and one can only hope that the Co-operative Department may be able to do something to lighten this difficulty. Still, there is a sufficient number of landowners with means to make a beginning, and when a conservative country like China, with its traditional methods of maintaining soil fertility, doubled its already considerable consumption of sulphate of ammonia between 1925 and 1926, mainly for paddy as I am informed, there appears to be no reason to doubt that some progress can be made here too.

NOTE.—Since writing the above, these new manures have been placed on free list and freed from duty with effect from 5th May, 1928 D. H.

THE INDIAN AGRICULTURAL PROBLEM*.

BY

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I. Introductory.

Experience and study have combined to impress on me the supreme importance of the problem of Indian poverty, defined as the insufficiency of the national income to provide even the minimum requirements of a reasonable life for the bulk of the population. I look, therefore, on questions of distribution as important, mainly because of their reactions on production ; and I regard a large and progressive increase in the national income as the most urgent need of the time, the ideal being that every individual born in India should have a reasonable chance of developing his capacities to the utmost in the interests of the country as a whole.

I have seen it argued in the Indian press that such an increase in the national income can, or cannot, be obtained by developing agriculture, or by fostering industries, or in some other way or ways. My own view is that all such discussions are too limited in scope, and that what is wanted is a co-ordinated advance on the whole front, an advance common to agriculture in the widest sense—" fields, forests, and fisheries," as the term has been defined—to industry, both factory and domestic, and to commerce, internal even more than foreign. Having regard to the natural resources of the country, and to the aptitudes of the people, it is inevitable that, at any rate for some time to come, agriculture should play the most prominent part in the struggle with poverty, but it cannot hope to win without the co-operation of its allies. It is from this standpoint that I approach the Commission's terms of reference.

I may add that in the observations which follow, I am not referring to Burma, which I regard as a separate economic unit, and that by " India " I mean the whole country, including States as well as provinces.

II. The essence of the problem.

Leaving the reservations out of account, I read the Commission's terms of reference as an expansion of Plunkett's familiar slogan for peasant countries—Better Farming, Better Business, Better Living ; and in any case my observations will fall most naturally under these heads. At the outset, however, it may be well

*Memorandum for the Royal Commission on Agriculture in India.

to insist on the interdependence of the three elements. It may be affirmed with confidence that the welfare and prosperity of the rural population, which it is the Commission's main business to promote, will not come by technical advances alone; if it is true that better living can be secured only by a combination of better farming and better business, it is equally true that the will to live better must furnish the driving-power that is required; at the heart of the problem lies the development of the desire for a higher standard of living, and I believe that the time has now come when this question should be brought to the forefront of the discussion.

To say this is not to condemn Curzon's policy, in which stress was laid primarily on farming and on business. A quarter of a century or so ago, the ordinary opinion in India was that no great advance could be expected. There were dreamers, indeed, but their visions left plain people sceptical or unconvinced, and the first step necessarily was to show that the possibility of improvement existed. The work done since 1905 has furnished the required demonstration, and it can now be said with assurance that much better farming and much better business are within the reach of the Indian peasant if he cares to stretch out his hand. The offer of better things has been made and it has evoked a definite response, sufficient to show that the pioneers worked generally on sound lines, but so far, inadequate to produce the mass-effect required; and I suggest that, at the present juncture, the central problem before the Commission is how to strengthen the forces already at work, so as to turn a hesitating and inadequate response into an imperative demand. Such a change implies an effective desire for a higher standard of living; a vague aspiration now exists, and, I suspect, always has existed, but it is rendered ineffective by an inhibition, which has to be broken up before large-scale progress is possible. In other words, the central problem is now psychological, not technical. I shall return to this subject after I have recorded my views on a few of the technical questions raised by the reference.

III. Efficiency at the top.

Looking back over the last 20 years, the worst mistake seems to me to have been the delay in developing an efficient training college for the higher staff, but I understand that the required development is now in progress, or, if it is not, I apprehend that it must follow on the Commission's recommendations; while the most obvious anomaly in the existing structure, the organization of irrigation and veterinary services co-ordinate with, but distinct from, the agricultural department, calls for examination from the standpoint of practical results rather than general considerations. The only points to which I wish to invite the Commission's attention under the rubric better farming are the choice of the permanent head of the provincial department, whom I shall speak of as "the Director," and his relations with the Provincial Government. I consider these subjects to require close scrutiny, because the demands on the Director will increase more than proportionately to any extension of operations, and if, as I anticipate will be the case, the result of the Com-

mission's labours will be a large extension, it is imperative to take precautions at the outset against the danger of inefficiency at the top.

I know of no published pronouncement regarding the qualifications of the Director, and consequently the subject must be discussed in some little detail. It is hopeless to look for a Director expert in all branches of departmental activity ; the mid-Victorian agricultural-chemist-of-all-work was already obsolescent when the first agricultural chemist was sent to India, and the progressive specialization of science renders such an appointment unthinkable. The appointment of a specialist in a single branch of scientific activity stands on a very different footing ; its only advantage is that it will ordinarily secure sympathy with scientific method, but that advantage can be secured in other ways ; and on the other hand, there is the danger, which will increase with the progress of specialization, of an unsatisfactory distribution of resources, or, in the alternative, of dissatisfaction with a distribution which in itself is sound. One of the main duties of the Director is to distribute resources, which are usually inadequate, between the various branches, each, very properly, demanding more than it can get ; and it is in accordance with human nature that, let us say, an Entomologist-Director will give entomology something more than its fair share, or, in the alternative, that chemists and physicists, botanists and mycologists, will say that he is doing so. The existing practice of appointing specialists as Directors is not therefore unassailable in theory ; the question, however, is whether it is the best way of getting what is wanted.

The indispensable qualifications of a Director are two—skill in the art and practice of administration, and knowledge of the economics of peasant life. The first of these is obvious, and all I need say regarding it is that its importance increases more than proportionately with the expansion of the Department : having regard to the requirements of a peasant population of 30 or 40 millions, it must be recognized that each of the larger provinces will ultimately need a Director of the very highest administrative ability. The second qualification is not less obvious : the Director has to apply the resources at his disposal for the benefit of the peasants, and he cannot do this effectively without knowledge of the mentality, the capacities, and the limitations of the men for whom he is working, men who do not wear their hearts upon their sleeves, men whose confidence must be won slowly, and by personal contact, men who at present have practically no interpreters in the Indian press or in Indian public life. In the absence of such knowledge, the department cannot possibly perform its functions ; and, so far as I can see, the knowledge must be possessed by the Director himself, because a Staff-Economist, appointed to make good the Director's deficiency, would in practice be indistinguishable from a *de facto* Director.

In regard to these indispensable qualifications, I think, it must be recognized that the position has changed for the worse, and that the practice of appointment followed 15 or 20 years ago offered a better prospect of securing them than the practice of the present day. Under the old practice the Director was chosen from

the Administrative Service, a fact which guaranteed at any rate some knowledge of administration, while the choice was determined largely by his knowledge of rural life. Commonly, he was a successful Settlement Officer, that is to say, he had assessed the land revenue of one or more districts, and there could be no better guarantee. The organization and conduct of a settlement was in those days a large administrative task, success in which marked a competent administrator; while there was no other way of acquiring an equally minute and precise knowledge of rural economy. In addition, it may be noted that officers who joined the Administrative Service before 1893 had the advantage of a thorough grounding in analytical economics, which greatly facilitated the grasping of the multifarious economic facts with which the Settlement Officer, like the Director, has to deal.

During the last 30 or 40 years, the different specialist services in India have gradually made good a claim to the headship of their own departments, and in the Agricultural Department, I understand, that most of the Directors are now specialists. Let me make it quite clear that I do not say that they are therefore necessarily incompetent, or that the older system should be restored; my argument, so far, is simply that, in this particular case, the specialist department is a less hopeful recruiting-ground in the present than the Administrative Service was in the past. Within it, there are of course great differences. The specialist agricultural officers known as Deputy Directors are sometimes in a position to acquire the art of administration by practice, while their duties give opportunities for getting very close to the peasant. Some of them, to my knowledge, have made the most of these opportunities, and, in my judgment, are perfectly fit to direct the department; others, in my judgment, are not. The laboratory specialists—chemists and botanists, mycologists and entomologists, and so on—have fewer opportunities of the kind, and their opportunities are likely to diminish with the progress of specialization; as Directors, they must be, at the best, amateurs, and while the amateur-administrator and the amateur economist are not yet extinct, they must be regarded as doomed species.

The method of appointment from this recruiting-ground is, I understand, described officially as selection, but in India, as in other countries, that term has acquired a special significance. In practice, it does not mean choosing the best man irrespective of his position on the list, but rather appointing the senior man who is not obviously unfit, and any other interpretation would probably be destructive to efficiency owing to the resulting discontent among the staff. I suggest that the actual position is this: under a system of strict selection, the Agricultural Service, taken as a whole and neglecting provincial boundaries, is possibly in a position to supply the required number of competent Directors, with not more than the usual proportion of bad appointments; but under the existing Constitution provincial boundaries have acquired new importance, which is certain to increase; and, if appointments are normally made within the province on the system of seniority-tempered-by-rejection, the number of misfits is likely to be much too large.

For reasons already indicated, I am not in a position to discuss the facts of the appointments actually made under the new system, and I will say only that a good deal of the departmental literature which I have recently read is characterised by a native amateurishness in economic matters such as was rarely met with a quarter of a century ago. What I suggest is that the Commission should examine, in confidence, the circumstances of the appointments made under the new system, with regard in particular to (1) the influence of seniority, (2) the attention paid to securing what I have called the indispensable qualifications for the post; and that, on the facts so ascertained, it should formulate principles, to be expressed either as statutory rules or as administrative maxims, as the circumstances may require, to ensure the possession of these qualifications in the Directors to be appointed in future.

IV. MINISTERIAL CONTROL.

I turn to the relations of the Director with the Provincial Government. Here again, I think, it must be recognized that there has been a change for the worse. Under the old system the Director was, as I have said, usually qualified as administrator and as rural economist, but in any case these qualifications were always present in the Provincial Governments, at least of Northern India. Lieutenant-Governors were necessarily expert administrators, while they were in fact usually distinguished also by their knowledge of rural economics. As an instance, I served successively under Colvin, Crosthwaite, MacDonnell, and La Touche, men whose writings are indispensable to any careful study of the economic history of the North, and other provinces can tell a similar story. In such an environment a Director's shortcomings were likely to be promptly noticed and effectively corrected; while the whole constitution of the provincial hierarchy was such as to give rural economics the importance which in a rural province the subject can justly claim. Considerations of a different order now necessarily enter into the selection of Governors, and it is much less likely than it was that the position will be held regularly by a rural economist of distinction. Even, however, if it were so held, the Governor of to-day is deterred by constitutional considerations from controlling the Director in the old way; that is the duty of the Minister.

Political arguments must be kept out of this note, but it is strictly relevant to my contentions to say that more than 10 years ago I had come to the conclusion that, on purely economic grounds, the Agricultural Department and its allies should be placed under popular control as soon as possible; and, as a student of economics, I welcomed this step when it was taken, because I looked to Ministers to supply the leadership and driving-power which were, as they still are, required for a serious attack on the problem of Indian poverty. The appointment of the Commission is of itself sufficient evidence that these hopes have not yet been realized; but the immediate point is that Ministers, however effective they may be as leaders, cannot be expected to possess, except by accident, the administrative and economic quali-

fications which were normally possessed by Lieutenant-Governors and their bureaucratic advisers in the past. The Director can look for less help from above, and consequently he must be more nearly self-sufficing in the matter of the indispensable qualifications. The change in control thus strengthens the argument offered in the preceding section for devoting special attention to the method of appointing Directors.

But, if the Minister cannot help in these matters, he may do a great deal of harm. The dangers of which I hear from India are two: he may try to administer the department instead of controlling it, and he may hamper that continuity of effort which is essential to success. Each of these dangers calls for the attention of the Commission.

As regards the first, it must be remembered that there has not been time for constitutional practice to grow up in India. The rawest recruit in an English Ministry knows, or learns very quickly, that his business is to control but not administer; that doctrine requires, I suggest, to be brought prominently to the front in India. The classes from whom Indian Ministers have usually been drawn have the idea of bureaucracy in the place where Englishmen have the idea of self-government; it is in their bones, and no surprise need be expressed if a newly-chosen Minister should feel as if he had climbed into the bureaucracy at the top and should settle down to administer his departments as Indians of his class have always done—at any rate since the days of Asoka. Such a result must necessarily be injurious, and the best way of preventing it seems to me to lie in the formulation of a definite constitutional doctrine, which, coming with the authority of the Commission, will, I anticipate, be accepted readily enough.

The second danger follows necessarily from what is, I fear, a permanent fact, that the department normally wants larger resources than it can obtain. A Minister is absolutely within his rights in formulating a popular programme and requiring the department to carry it out; the danger is that, in order to carry out his programme, he may curtail existing work of much greater importance to the country and, in particular, that he may interfere with continuity in research. In my time I had to fight for recognition of the principle of continuity against financial authorities who appeared to be under the impression that organization generally, and research in particular, could be expanded and contracted like a concertina. When I left India, the battle had been practically won, so far as the bureaucracy was concerned. The principle was, however, ignored in some of the recommendations of the Inchcape Committee, and it may be worth while to quote against them the conclusions of a not less authoritative body of business men, the Royal Commission on the Coal Industry (1925), whose report contains the following remarks (page 43):—

"We are strongly of opinion that research work can only be carried on efficiently if the organisation concerned is in a position to develop its programme logically and steadily, and that nothing is so conducive to inefficiency and to wasteful expenditure as instructions to develop the work alternating with instructions to con-

tract it. Steps should therefore be taken to ensure that the organizations concerned are in a sound financial position, so that they can develop their programmes in a methodical manner over a period of years."

I make this quotation because it seems to me to offer a sound basis for constitutional doctrine, which could be formulated with great advantage to the country. A Minister, I suggest, ought not to contract important work already in progress in order to carry out a new programme; if additional resources are needed for his programme, his duty is to ask for them from the Legislature, and, if his request is refused, he must either accept the Legislature's decision or resign his office.

The object of this section is, then, to suggest that the Commission, after ascertaining the facts by confidential enquiries, should formulate, for adoption in India, a constitutional doctrine regulating the relations between the Minister and the Director in such a way as to obviate the two dangers to which I have referred, as well as any others which enquiry may show to have arisen.

V. The co-operative movement.

From better farming I pass to better business. The subject has two aspects: co-operation, and business other than co-operative. In regard to the co-operative organization I have not much to say. The present position seems to me to be similar in essentials to that of the agricultural department. The preliminary work has been generally on the right lines: expansion now depends more on the people than on the Government; while, so far as the Government is concerned, the most important topics are the head of the department, *i.e.* "the Registrar," and his relations with the Minister.

The Registrar, I suggest, needs the same indispensable qualifications as the Director, and some others in addition, which are indicated, but not defined, in the familiar phrase, "a financier who is also an apostle." I believe that the Commission will find a close correlation between success or failure in the various provinces, and the qualifications of the men who have filled the post; in fact, that the situation was justly estimated in Nicholson's aphorism, "Find Raiffeisen," which, however, requires the addition, "when you have found him, keep him as long as possible." The most important need under this head is, then, to formulate administrative rules or constitutional maxims regarding (1) appointment and tenure, and (2) relations with the Minister, which may operate to prevent misfits and misfortunes, such as the Commission may find reason to apprehend.

The only other branch of co-operation to which I wish to refer is that of sale and purchase. Experience has, I think, amply justified the decision of the pioneers to concentrate on credit at the start; but we are now nearing the stage, if we have not actually reached it, where other branches of co-operative business require to be actively developed. Better farming and better business are very closely interdependent; improvement in agriculture means that peasants will have more to sell and consequently more to spend; and, seeing that they now usually get the worst of

the bargain both ways, improvements in marketing will be needed more and more as the volume of transactions expands, or else good farming will be checked by bad business. I notice in recent reports that attention is being given to this subject in some parts of India, but I suggest that the Commission may find it advisable to recommend more detailed study of the subject in order to facilitate developments in accordance with the requirements of the near future.

I feel bound to add that the shortness of this section does not indicate my opinion as to the importance of the topics with which it deals. Our views of the possibilities of co-operation expand with the experience which tells us of the dangers which beset it, and I write as a convinced adherent of the co-operative faith; but the practical problems of the moment can be studied only in India, and I must leave their discussion to others.

VI. Internal commerce and transport.

I consider it to be possible that all the peasants' business may ultimately be conducted on co-operative lines; but the vision is somewhat distant, and the Commission will have to provide for the interval, probably of considerable duration, in which much of the peasants' buying and selling must be conducted through other agencies, as all of it is now conducted. The actual position is that the peasants, unorganized and ill-informed, buy and sell through a complex agency, very highly organized, very well informed, and dominated by its own interests rather than those of its customers. This agency undoubtedly does the peasants' work; the question is whether it charges too high for the services it renders. The conditions I have stated show that over-charge is, at the least, probable; and the only checks on it are competition within the agency, and State action where such competition is not fully effective.

In regard to competition, a distinction must be drawn between the internal and the external portions of the agency. Looking at the peasant as seller, the European wholesale markets for his produce are highly competitive, and it may fairly be said that his goods fetch the world-price on the Baltic, in Mincing Lane, and elsewhere. The freight market again is highly competitive, and I am informed, though I have no first-hand knowledge, that this is true also of exchange-banking at the present time. The Indian exporter is thus ordinarily in a position to secure the world-price without excessive deductions for charges outside India; and we have to look at the intermediaries between exporter and peasant, the ports, the railways, and inland commerce.

As regards seaports (a term which I use as covering not merely port dues, but the whole commercial organization linking the railways with the ships), the conditions favourable to the peasant are active competition between the ports for business, such as prevails in England. In India there has of late been a welcome development of harbour-construction in the south, but the north remains as it was; excluding the special trade of Chittagong, there are three seaports for a population of nearly

200 millions, a position which may be contrasted with New Zealand's 46 ports for a population of about a million and a quarter. For analogies to the position in India we must look rather to Australia and Canada. Even a rapid journey through south-east Australia suffices to familiarize the traveller with the groans of producers at the monopolistic domination of Melbourne and Sydney, "bloodsucking leeches" as I have heard them described. In Canada we have the extraordinary tale of the Hudson's Bay Railway, a line being built through a wilderness to a port scarcely yet in existence, and available only for a short annual season, forced on the Government by the efforts of organized grain-growers, who are determined to free themselves from the incubus of New York and Montreal. Where, as in northern India, seaports are few, each of them has the monopoly of the bulk of its hinterland, the competitive fringes being relatively small, and the case is definitely one for State action on behalf of the peasants, by increasing seaports where possible, and by ensuring that they are worked primarily in the peasants' interest. The apparent impossibility of creating new seaports for the north makes it all the more necessary to control the few which exist.

The same conclusion holds in regard to railways. The recent extension of State management, and the adoption of what has come to be called grouping, will go far to eliminate such competition as has existed in the past, and necessarily throw on the Central Government the duty of seeing that the railways meet the peasants' requirements at reasonable cost.

The third branch of the internal organisation, inland commerce, requires more detailed treatment. I affirm that ordinarily the peasant gets the worst of the bargain, both when he buys and when he sells, and that this condition is due partly to the system and partly to the inspiration under which the system has grown up. I do not anticipate that the Commission will be able to investigate this question in full detail, but I believe that the facts which are readily available will satisfy its Members of the truth of my contention. One most important group of facts will be found in the Report of the Indian Cotton Committee (1919). The malpractices in the cotton trade revealed in that report shocked enlightened India sufficiently to render feasible the drastic special legislation which is now in force, and which, according to the last Report of the Central Cotton Committee, is producing satisfactory initial results. My point is that these malpractices were not confined to the cotton trade, but are, and long have been, characteristic of Indian commerce, and, so long as they continue, good farming will be checked by bad business.

In this matter I speak from considerable personal knowledge. Whenever I had occasion to examine the inland trade in agricultural produce, I came across the same features—mis-grading, mis-description, adulteration, false weighing, and, occasionally, fraudulent accounting, though from the nature of the case this last item is not easy to detect. In regard to these matters I need not enter into detail the Commission will be able to ascertain how far the experience of other rural economists coincides with mine; and it will suffice if I point out that, while the system is bad

for agriculture as it stands, it is even worse for the better farming which is wanted, because the trade, as now organized, will not pay price for quality, and the peasants are therefore forced to look to weight of yield, to the exclusion of what is often more important, value per unit of weight.

I have said above that these malpractices are of old standing. I must avoid a disquisition on economic history, and will say only that the Dutch and English commercial records of the early seventeenth century disclose a condition similar in all essentials to what was described by the Cotton Committee. The vicious system of internal commerce consists essentially of the exploitation of peasants, who are usually bound to sell, by men of quicker brains, who for the moment can refuse to buy, and who act in the spirit which has been generated by centuries of such conduct. As it stands, it can probably kill co-operative trading at the start, and its reform is required in the interests of the peasant of to-day and still more of the peasant of to-morrow.

Another source of information which is readily open to the Commission is the opinion held by the peasants of those exporting firms which send their buyers up the country to deal directly with producers. The eulogies of these firms which I often heard from Oudh peasants convinced me that the presence of their buyers was a great asset, but at the same time I saw no reason to suppose that they were philanthropists; the points which the peasants selected for praise were merely the elements of honest commerce, fixed prices, fair grading, true weighing, and straightforward settlement; and if these are matters for grateful eulogy, it follows that they are not features of ordinary inland trade.

So far this analysis has regarded the peasant mainly as seller, but it applies generally to him as buyer also, with two not unimportant modifications: in the distributing trade there is scarcely anything to correspond to the exporting houses just mentioned, while in regard to imported and protected goods, the peasant has to bear the weight of a heavy town-bred tariff, loaded of course by middlemen's charges on their enhanced outlay. On the whole, then, he is rather worse off as buyer than as seller, but he will generally have to sell more than he buys, because he has to pay rent or revenue in cash; and, speaking generally, it seems to me that the present state of internal trade, particularly as it affects interchange between town and country or between one district or province and another, offers a very serious obstacle to the improvement of agriculture.

VII. The Central Government.

The argument of the preceding section leads directly to the conclusion that the Commission must concern itself with the activities of the Central Government, which now manages most of the railway system, which controls the larger seaports, and which is responsible for, at any rate, external and inter-provincial commerce. Here again the position of the peasant has changed for the worse. The old Revenue and

Agricultural Department, with its record of great rural economists from the days of Buck onwards, has now been eliminated, and, for obvious reasons, fewer portfolios in the Council are likely to fall to rural economists than formerly, while those departments which are concerned with ports, railways, and commerce are traditionally influenced by the towns rather than the country. The question therefore arises: do the interests of the peasants dominate the proceedings of the Central Government, both in the Council and in the departments, as on any theory of government, whether autocratic or democratic, they ought to do? Is the peasant now what Curzon declared him to be, "the first and final object of every Viceroy's regard"?

The Commission will be able to answer these questions from its own experience in India, and I will say only that, if the peasant dominates the Council, the fact has not appeared in its pronouncements during the last few years. One recalls an admission that the Tariff Bill might never have been brought before the Legislature if the peasants had understood the question; one studies in a series of communiqués the somewhat tortuous course of the proceedings which led eventually to the appointment of the Commission; one notes in the debates an occasional presentment of the peasant's case by one of the provincial representatives; but one looks through recent records in vain for evidence of that union of knowledge and sympathy which ought to characterise the Central Government of a peasant State.

I suggest to the Commission that in this matter atmosphere is more important than machinery. It would be easy to propose institutions of the kind known popularly as "watch-dogs," departments or officials charged with the specific duty of representing the peasants' case, particularly in the initial stages, when new projects have not yet taken definite shape; but it is much more important that the framers of the projects should themselves be influenced by the peasants' needs. It may be worth while to illustrate this contention from my own experience. During a period of more than 10 years I had occasional discussions with railway administrations at five different centres regarding the needs of the peasants in various parts of the United Provinces, and the difference in atmosphere was remarkable. At Gorakhpur I used to find eagerness to help the peasant on commercial terms, coupled with, at any rate, sufficient knowledge of his position to make discussion of details an easy matter; at Lucknow there was normally sympathy, but it was sterilized by ignorance of what went on outside the railway fence; at Lahore there was sympathy, but (as was only to be expected) little knowledge of the special needs of an outlying portion of the huge system; in Bombay, as in Calcutta, the correspondence gave no hint that the authorities either knew or cared anything about these distant and insignificant peasants. I state these facts as illustrations of my contention that atmosphere matters most, not as showing the conditions which exist to day; the contention applies with particular force to the railway administration, but it applies also to various other departments and to the Central Government as a whole. I suggest, then, that this question should be examined in detail; possibly the Commission may recommend some changes in administrative machinery, but the main

advantage I look for is the influence which it can bring to bear on official and public opinion. Ventilation will, at any rate, do something to improve the atmosphere.

It may be conceded that in the present conditions the peasants' best safeguard would be the emergence in the Legislature of a strong and stable Peasant Party. Such a development is not impossible, and it may conceivably be hastened as an indirect result of the Commission's activities; but the actual position is that such a party does not exist, that its development will be a matter of time, and that the task of the Commission, as I see it, is to secure better business for the peasant in the interval which will elapse before he can control his representatives sufficiently to get what he wants.

VIII. The will to live better.

I now come to the sphere of better living, which I take to be the main concern of the Commission. It is true that better living can come only as the result of better farming and better business working together; but it is equally true that the will to live better must furnish the driving-power, without which improvements in agriculture and commerce will not give an adequate return. The conclusion forced on me by experience and study is that the mere offer of increased material facilities, taken by itself, tends to bring into action forces which will ultimately render it nugatory; it is merely the initiation of one more vicious circle of the kind already so familiar in the Indian economic world. On the other hand, to arouse the will to live better is to set in motion the only known force working cumulatively in the desired direction; the result is not a vicious circle, but an upward slope, where, in the early stages, the gradient gets easier at each step. In the first case the result is likely to be an increase in the number of people living in the old way, and, ultimately, renewed congestion; in the second, the result will be a population of greater civic worth, doing progressively better work, earning a progressively larger net income and devoting successive increments largely to provision for a further advance.

Now the dominant feature of rural India at the present day is that the will to live better is not a force to be reckoned with except in particular circumstances. Various theories have from time to time been put forward to account for this divergence from the norm, as it appears to Western observers. The older theory, that the aspiration to rise was left out when the Indian peasant was created, is sufficiently disposed of by the fact of its sporadic appearance, and does not call for detailed examination. Modern experience regards the peasant as an ordinary human being, in whom the natural aspiration is checked by an inhibition generated by the environment; but there is a difference of opinion as to whether it is the physical or the human environment which is responsible. Some authorities put the blame wholly or mainly on the climate, but, so far as I can see, they fail to take account of the facts that the climate of India is characterized by great variety and that differences in peasant-mentality are not correlated with differences in temperature of humidity. To give only one instance from my personal experience, the climate of the country round

Cawnpore is the antithesis of the climate of the Malwa plateau, about 300 miles away, but the mentality of the peasants in the two regions is substantially the same. I suggest that the effect of climate should be regarded as secondary, and as operating mainly to increase the strength of an inhibition which is essentially the result of the human environment.

No one who has seriously studied the economic history of India from the twelfth to the eighteenth century can deny that, subject to local and temporary exceptions, the human environment from one end of the country to the other was such as would necessarily produce a servile mentality, with the aspiration to rise held in effective check. It was fatal for a man to raise his standard of life, because to do so marked him out as fair game for robbers and extortioners; to be "suspected of property" was a dire calamity, and those men only could be accounted happy who could spend their day's wages on their evening meal; "the land would give a plentiful yield if the peasants were not so cruelly and piteously oppressed"; "give the poor people leave but to lift up their heads in one year's vacancy from oppression"—such phrases as these, taken from Portuguese, Dutch and English writers of the period, give an idea of the environment in which the peasant lived, an environment which penalised productive effort, which necessitated the concealment of any surplus income that might accrue, and which operated to stereotype the low standard of life which offered the only chance of being let alone. I do not know the conditions which prevailed in India before the twelfth century; I suspect that the Moslem conquest did not make a very great difference in this respect, but I am content to affirm that six centuries of this régime furnish adequate explanation of those features of the peasant's mentality which now constitute the main obstacle to economic progress.

When, therefore, I say that better living is the main business of the Commission, I am not inviting its members to reform, or even to counteract, the Indian climate; I am suggesting that they should devise methods to strengthen and accelerate the forces already operating to dissipate an inhibition, which was undoubtedly useful in its day, but has survived its usefulness and become a danger. Let us glance at a few cases where results in this direction have already been obtained.

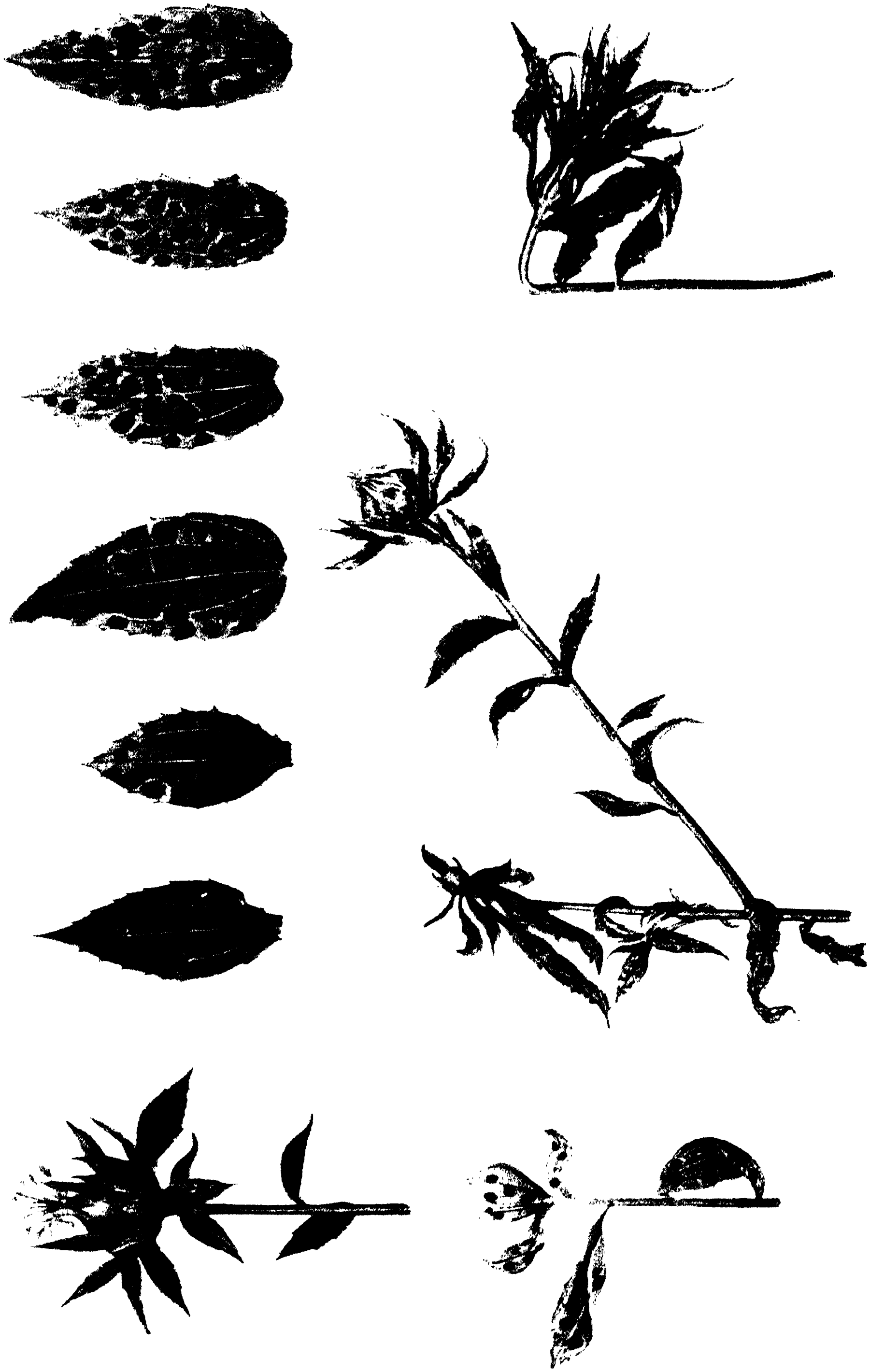
The most striking case is the Punjab since the war. In his study of *The Punjab Peasant in Prosperity and Debt*, Darling tells us (page 289) how the Punjabi soldier in France "saw an entirely new order of rural life, and realized with surprise that the village can be as civilized as the town. The sight of the French peasant, educated, prosperous, and independent, has roused in him a discontent with his own surroundings that will not be easily allayed." In other words, the secular inhibition has been dissipated by a year or two's experience, not, I suggest, of the French climate, but of a human environment in which peasants are able to live a reasonable life on resources not very much greater than those available in the Punjab. The returned soldier is now trying to raise his standard, his influence is extending to his neighbours, and as Darling justly observes, "never has the time been more propitious for grappling with the problem of poverty and waste".

Again, it is a commonplace of the Census Reports that conversion to Christianity is often accompanied by a development of the will to live better; the converts "want to live like Christians," and some of them succeed. The same phenomenon can be observed when Hindus of the lower classes become Moslems; when the Cawnpore leather-worker (*chamar*) becomes a Shaikh, he tries to live like a Shaikh; and in these instances there is no question of a change in the physical environment. It is sometimes alleged that in such cases the will to live better is the motive rather than the result of conversion; this question is immaterial to my argument, which is that the inhibition is wearing thin, and that in certain circumstances individuals are surmounting the obstacle. In any case, to recommend a change in religion with this object would be about as reasonable as to recommend another continental war; and having regard to the present Indian attitude towards conversion, and towards emigration, it must be said that the instances given show that the thing can be done, but do not show how to do it on a large scale.

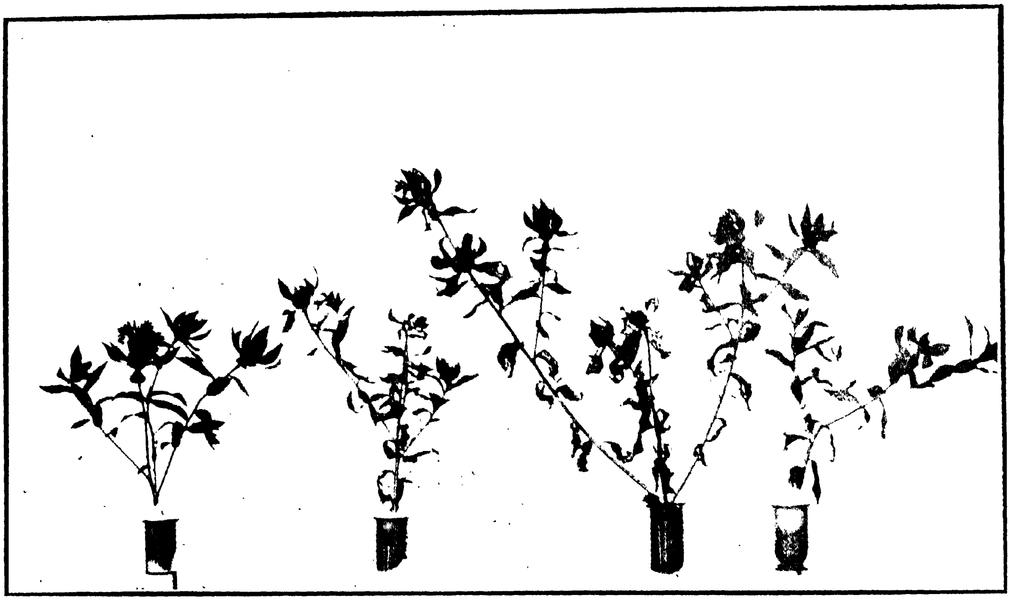
Many less conspicuous instances of the said tendency could doubtless be found in the course of a detailed survey of Indian conditions. I can recall villages in Oudh which lived better than their neighbours because the tone in them was set by returned migrants from other parts of India, and I do not suppose that my experience is unique; but what I have written appears to me to be sufficient to justify the view that the inhibition against better living is wearing thin, and in a few places cracking; the main task of the Commission, as I conceive it, is thus how to strengthen the forces already in operation, and how to summon new forces to their aid; or in other words to promote mass-education in the widest sense.

(*To be continued.*)

PLATE XXVII.



Diseased leaves and branches of Safflow



1

2

Photographs of healthy and diseased shoots. To the extreme left in figures 1 and 2 are the healthy shoots.

A LEAF-SPOT DISEASE OF SAFFLOWER (*CARTHAMUS TINCTORIUS*) CAUSED BY *CERCOSPORA CARTHAMI*, NOV. SP.

BY

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SAFFLOWER (*Carthamus tinctorius*) is cultivated widely in many parts of India, especially in Bengal, Central Provinces, United Provinces and Bombay. In the south, however, it is restricted to parts of Mysore and the Ceded Districts. In the Madras Presidency, safflower is very rarely cultivated as a crop by itself. It is generally grown mixed with other crops. Very often it is sown as a sort of hedge round some other crop, its spiny leaves effectively checking the intrusion of cattle. A dye is extracted from the florets and the seeds contain an oil which is largely used for cooking purposes as well as for adulterating ghee.

Of the diseases of safflower not many are recorded. Joshi [1] has described a wilt of safflower caused by *Sclerotinia* sp. in Upper India. In Saccardo's "Sylloge fungorum," *Puccinia Carthami* has been recorded as affecting safflower leaves.

A leaf-spot disease of safflower caused by *Cercospora* sp. has been observed several times in the Central Farm, Coimbatore. It was first noticed in the year 1921 when it appeared in an epidemic form. Since then the disease has been noticed in 1922, 1924 and 1925. It has so far been observed in Coimbatore only and it is not known whether it is present in other places as well.

As is the case with all *Cercospora* diseases, a humid atmosphere favours the prevalence and spread of this disease. In Coimbatore it has been found that in all the years in which the disease appeared, the atmospheric humidity at the commencement of the disease was about 80 per cent. Rains increase the severity of the disease. In the earlier part of January 1922, the disease was at a minimum. In February (in the same year) there were heavy rains and the disease became very severe. Again in October 1925 only a few spots were present on the lower leaves, but after the heavy rains in November the entire crop was diseased. The severity of the disease is thus found to be directly dependent on the atmospheric precipitation.

The disease makes its appearance at various stages of the growth of the plant.

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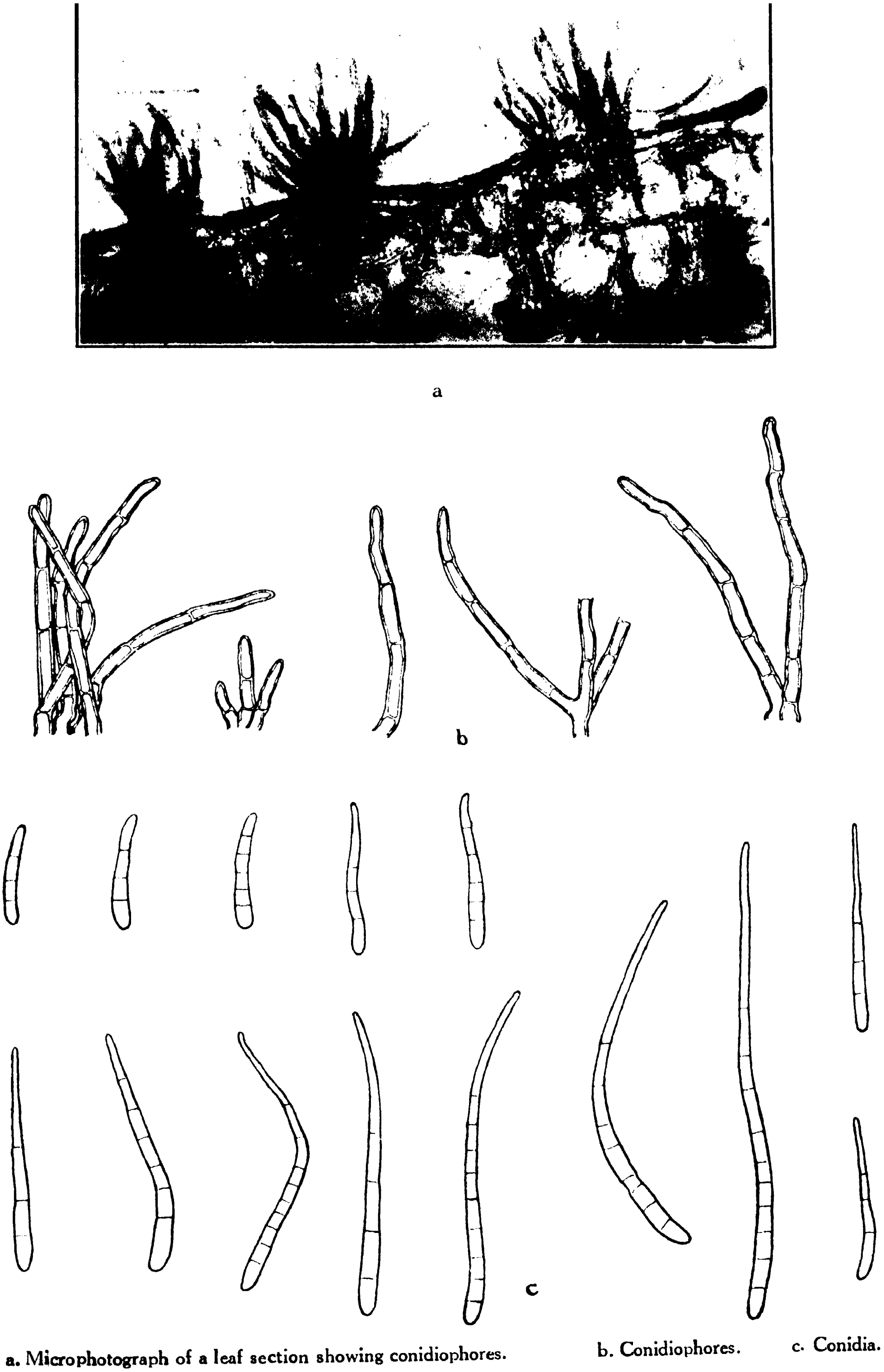
[1] Joshi, S. D. A. Wilt Disease of Safflower. *Mem. Dept. Agri. India, Bot. Ser.*, XIII. No. 2.

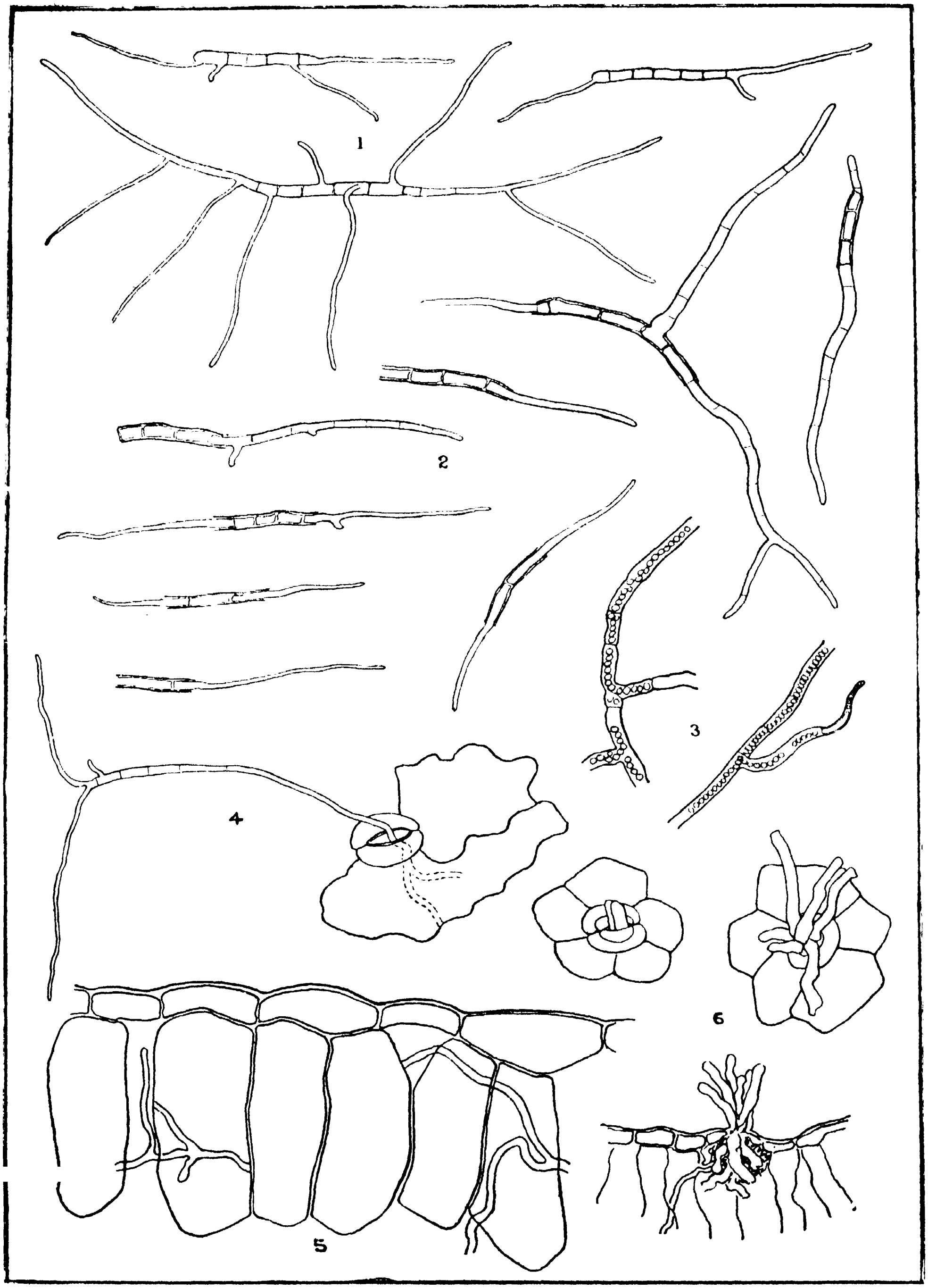
Sometimes it is observed only when the plants are about to flower. But it may appear even earlier, *i.e.*, a month after sowing—as isolated round brown spots on the lowermost leaves, which under favourable conditions, may later on spread on to the upper leaves also. As the name indicates, the first appearance and effect of the disease are on the leaves. Small, round, slightly sunken, brown spots with at times a yellowish tinge at the border appear on the lower leaves. The shape of the spots varies, being round or irregular, most of those formed in the middle of the leaves being round, while those formed at the tip or nearer the edges being irregular or semicircular. As the disease advances, the majority of the leaves become affected. Badly infected leaves turn brown and get distorted and eventually the tissues disintegrate and holes are formed between the veins presenting a worm-eaten appearance. Fructifications of the fungus are present as minute black dots on both surfaces of the spots. In the early stages and on dry days the surfaces appear black, the conidiophores sticking up as minute processes. But under humid conditions and in the mornings the surfaces of the spots present a greyish white velvetty appearance due to the production of spores. The attack of the fungus is not always confined to the leaves. The bracts are also spotted and in severe cases the entire capitulum may be infected. If the head is affected in bud, it turns brown and withers and the florets do not open. But if the attack is just when the florets open, the latter shrivel up, the head becomes dark brown in colour and no seeds are set. When the attack is only after the seeds have begun to form, these are not appreciably affected. In cases where the entire leaves are infected, the particular nodes are also blackened. At times the stem is affected for some distance especially below a young or tender infected capitulum presenting a die-back appearance. It is shrunken and blackened, sometimes being even bent. Fructifications of the fungus are seen on the affected portion of the stem also.

The mycelium of the fungus is hyaline in the earlier stages but gradually gets a smoky brown colour. It permeates the tissues of the leaves both between and across the cells. Prior to the spore formation, hyphæ collect in the air spaces underneath the stomata and often a brown stroma-like structure is developed. From these, conidiophores originate and come out through the stomata, a varying number being given off from each stroma. The conidiophores are produced on both the surfaces of a spot and appear *en masse* as minute black dots. They are simple very rarely branched septate and brown, the tip sometimes presenting a knee-joint appearance. In sections of leaves the conidiophores of a group may sometimes have a corymboid appearance, all of them coming up to the same level, the outer ones being bent at the base. They measure on an average $150{\cdot}8 \times 4{\cdot}6\mu$. But the length of the conidiophore seems to be very variable ($104{\cdot}75$—$209{\cdot}5\mu$) and dependent on the moisture relations. Increased humidity results in a corresponding increase in the length of the conidiophore also. The conidiophores germinate readily in water with the production of germ tubes. In addition to entire conidiophores even broken bits of these germinate. The germ tubes are given off from



a. Microphotograph of a leaf section showing conidiophores. b. Conidiophores. c. Conidia.

PLATE XXX.



1. Germinating conidia. 2. Germinating conidiophores. 3. Hyphæ from Congo red agar. 4. Mode of penetration. 5. Section of a newly infected leaf showing the mycelium inside. 6. The emergence of the conidiophores through stomata.

either end as well as from a side. The germ tube given off from a broken end appears to originate from a septum and grows out through the broken end of the conidiophore.

The spores are hyaline, elongated and septate and produced at the tips of conidiophores. The length of the spores again is extremely variable and to some extent dependent on the humidity. The spores from leaves collected one morning and measured immediately varied in length from 33·6 to 260μ. On another day it was slightly drier and the maximum length was only 140 μ. The spores are broadened at the base and taper towards the end in a whip-like manner. The breadth of the base of the spores varies from 3·2 to 6·3μ. The number of septa varies according to the length of the spores, 2 to 23 septa being noticed. In some cases one or two of the central cells of the spores are devoid of any contents and slightly shrunk, while on either side the cells are full of granular protoplasm. The spores germinate readily in water in 3 to 5 hours. Germ tubes are given off from both ends as well as from the sides. These are produced from most of the cells, each cell being capable of giving out a germ tube.

The fungus was easily brought into pure culture by transferring single germinating conidia into glucose agar tubes, and its growth on various media was studied. The growth of the fungus on agar media was not very quick.

On glucose agar the fungus produced a greyish white growth with a mealy or powdery appearance. The substratum was blackened. Later on the surface of the slant became dark grey in colour with a zonated growth.

On French bean agar also the growth had a powdery appearance with a blackened substratum, but the colour of the growth was more white than in glucose.

The growth on oatjuice agar was good. The substratum was greenish black and the hyphæ on the sides of the tube were smoke coloured. On the surface the growth was white in colour being slightly tinged with pink at the bottom of the tube. The powdery appearance noted in the first two cases was not observed here.

There was a good white growth of the fungus on cornmeal agar the substratum being greenish black as in oat juice agar. With age the top and edges of the slant also became black.

On *Carthamus*-leaf-extract-agar there was good growth with a white mealy appearance on the surface, the substratum being black.

A good greyish white growth of the fungus occurred on sterilized *Carthamus* stem. The surface of the stem was blackened. A number of conidiophores and conidia were produced.

On sterilized fresh *Carthamus* leaves black spots were formed and these gradually increased in number and size. A number of conidiophores and conidia were produced on both the surfaces of the leaves.

On autoclaved *Carthamus* leaves, a good dirty grey growth was formed. More of aerial growth occurred than on fresh sterilized leaves. Conidiophores and conidia were developed. The leaves were blackened.

Congo red agar. The growth was slower than in others. The matrix was black, the red colour of the agar was only eclipsed in the region where the fungus grew but not changed. A number of black sclerotia-like bodies were found both submerged and on the surface. Such bodies were not found in the other agars. The hyphæ were both hyaline and coloured, the latter being thicker and sometimes irregularly swollen. Inside the hyphæ were a regular array of rounded oil globules in coloured as well as hyaline hyphæ, producing an annulated appearance.

The fungus was grown on French bean agar of varying Fuller's scale to note the effect of the reaction of the media on its growth.

Reaction	Nature of growth	REMARKS
—10	Poor	The growths after 3 weeks were almost alike.
—5	Poor	
Neutral	Fair	
+5	Good	The best of the lot.
+10	Good	
+15	Good	
+20	Fair	The media did not set.
+25	Poor	

Evidently the fungus prefers a medium which is slightly acidic, *i.e.*, between +5 and +15 Fuller's scale.

In culture media a blackened thick substratum of closely matted hyphæ was always formed. The hyphæ were both hyaline and brown. In some media the hyphæ were sometimes swollen at intervals and presented a beaded appearance. Conidia were produced in agar cultures also but they were formed in larger numbers on the sterilised host material. They measured 52·5 to 224 $\times$ 3·5 to 6·1μ. and the number of septa varied from 2 to 13. Conidiophore-like structures were also present in some of the agar cultures, but these were slightly different from those formed on the leaves.

The parasitism of the fungus on safflower was established conclusively by series of inoculations.

Experiment No. 1. As a preliminary trial, fresh healthy branches of safflower with healthy leaves were cut under water and placed in flasks containing water. The leaves were washed with mercuric chloride solution and then with sterile water. The leaves in one branch were then inoculated by placing drops of water containing a suspension of spores collected from nature. The other flask was left as control. The flasks were kept in basins containing distilled water and covered over with bell jars. In 4 to 5 days small brown spots appeared on the inoculated leaves, while the control leaves were healthy. Conidiophores and conidia of *Cercospora* sp. were formed on the spots.

Artificially infected leaves.

Experiment No. II. *Carthamus* plants grown in pots were kept in glass cages with the bottom strewn with moist sand. The leaves of one plant were inoculated by placing drops of water containing a suspension of spores on them. Bits of agar culture were placed on those of another plant, while a third was kept as control. The inside of the cage was sprayed with water once a day to keep it moist. In 5 days spots were formed on the inoculated leaves—on the plants inoculated with spores from nature as well as on those with culture—while none were formed on the leaves of the control plant. Conidiophores and conidia of the fungus developed on the spots.

Experiment No. III. Young seedlings of *Carthamus* grown in pots with sterilised soil were inoculated with spores of the fungus from culture and covered over with bell jars. In 5 days spots were formed on the inoculated leaves, while the control plants were healthy.

Inoculations were made with the fungus on several other plants which are known to be hosts of species of *Cercospora*. Wherever possible, young plants in pots were used for inoculation, but in some (as tapioca and pomegranate) fresh healthy branches were kept in flasks of water and inoculated. Pomegranate fruits were inoculated and placed in moist chambers.

Plants inoculated	Previously known as hosts for	Result
Solanum melongena	*Cercospora melongenæ*	Negative.
„ *nigrum*	*Cercospora* sp.	Do.
Nicotiana tabacum	*Cercospora nicotianae*	Do.
	„ *Solanicola*.	Do.
Vigna catjang	„ *cruenta*.	Do.
Dolichos lablab	„ sp.	Do.
Canavalia ensiformis	„ sp.	Do.
Manihot utilissima	„ *manihotis*.	Do.
Punica granatum (leaves)	„ sp.	Do.
„ „ (fruits)	„ sp.	Do.
Vitis vinifera	„ *Vitii*	Do.
Arachis hypogea	„ *personata*	Do.
Brassica oleracea (cabbage)	„ sp.	Do.
Lettuce	„ *lactucae*	Do.

It was interesting to note that the fungus did not infect any of these plants. Of the several hosts tried, it infected *Carthamus* alone. Evidently, the parasitism of the fungus seems to be very much restricted.

To study the method of infection, suspensions of spores were placed on the leaves of young plants kept in flasks of water under bell jars. Eighteen hours after inoculation the spores and conidiophores were found to have germinated. The next day germ tubes from the germinating spores were found to have penetrated through the stoma of the leaves and grown inside. Having effected an entrance, the hyphæ ramified first through the intercellular spaces and later on across the cells. The cells lost their colour and shape getting distorted and crumpled. The infected

portions assumed a brownish tinge. The spots were at first very minute, of the size of a pin head, and sunken, and gradually increased in size. The hyphæ collected underneath the stomata and produced conidiophores which came out through them.

The disease can be prevented by the application of Bordeaux mixture to the plants before the disease appears. Since it is dependent on the humidity of the atmosphere, if the plants are given a protective spraying in time the disease can be checked.

On the Central Farm, a two cent plot of safflower which was diseased was taken up to study the effect of spraying. One half was sprayed with 1 per cent. Bordeaux mixture, while the other was left as control. The sprayed plot had 686 plants, while in the control plot there were 849 plants. The sprayed plot remained green for a longer time than the control one in which the plants became brown and dried up earlier. The yield from the control plot was 3 lbs. while that from the sprayed plot was 5 lbs. 2½oz. Ten plants were selected at random from the two plots and the weights of seeds from the individual plants were recorded separately. They were as follows :—

—	Sprayed plot	Control plot
	grm.	grm.
1.	6·97	7·21
2.	29·1	4·33
3.	5·46	4·6
4.	7·62	8·0
5.	12·9	3·06
6.	10·8	6·16
7.	16·72	7·13
8.	16·28	5·63
9.	6·2	2·78
10.	4·94	3·43
TOTAL	116·99	52·33
AVERAGE	11·7	5·23

The above results point out clearly the beneficial effects of spraying. Two varieties were grown at the Central Farm, Coimbatore, and both were found to be susceptible to the disease. It is possible that an examination of other varieties grown in other parts may show some variations with regard to the susceptibility to the disease and

breeding disease-resistant varieties may form a more economical method of combating the disease.

An experiment was laid out to note whether the disease is carried on the seed. Seeds from sprayed and unsprayed plots were sown separately, after steeping the seeds in 2 per cent. copper sulphate solution and without steeping. In a month small isolated spots were found on stray plants in all the plots and later on the disease developed equally virulently in all the plots. So the seed treatment is not found to be of much use.

The genus *Cercospora* is very widely distributed and occurs on a number of plants. The conidia and the conidiophores of the fungus are so variable in length and the measurements of these depend on the condition of the weather at the time of collection of the specimens that the measurements of the spores which are the usual criteria for the delimitation of species cannot be given prominence in this genus. The only other course seems to be to judge from the parasitism of the fungus or from cultural characteristics. The fungus under study was inoculated on several plants which are known to be parasitized by other species of *Cercospora*. It was interesting to observe, however, that the fungus persistently infected Carthamus alone and none else. This leads one to conclude that this fungus may be different from the others. It is therefore proposed to name this fungus as *Cercospora Carthami*.

Cercospora Carthami, nov. sp. Spots round or irregular, dark brown, slightly sunken, isolated or confluent. Hypha both inter and intracellular, hyaline and coloured, septate. Conidiophores produced in clusters, septate, brown, simple very rarely branched, 104·75—209·5×4·6 μ. Conidia hyaline, linear, tapering, sometimes slightly curved, 33·6—260×3·2—6·3μ, the number of septa varying from 2 to 23.

Habitat. On the leaves, bracts and stem of *Carthamus tinctorius* in Coimbatore.

Welles, C. G. Taxonomic studies on the genus Cercospora in the Philippine Islands. *American Journal of Botany*, Vol. XII, Pages 195 to 218.

NOTE.—Since sending this paper to the press several other diseases of this plant have been reported. From Middle Asia Zaprometoff has described *Ramularia carthami* causing brown leaf spots. In Siberia Mourashkinsky has recorded on *Carthamus tinctorius* the following: *Septoria carthami* and *Cercosporella carthami* causing leaf spots, an undescribed species of *Oidium* causing mildew and *Helminthosporium* sp. and *Fusarium* sp. causing the rot of newly formed seeds. [*Review of Applied Mycology*, Vol. VI, pp. 124 and 354].

TUBE WELLS AND AGRICULTURE.

BY

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THE annual Review of Agricultural Operations in India, 1926-27, written by Dr. Clouston, C.I.E., Agricultural Adviser to the Government of India, contains a section dealing with irrigation by tube wells. Dr. Clouston has asked me to contribute an article on this subject to augment his own remarks—an opportunity which I welcome in the hope that my labours in this field may be of interest and value.

My introduction to tube well engineering dates from the year 1912, when I witnessed and assisted in what was probably the first serious attempt in India to draw water in quantity sufficient for irrigation from the sub-soil by means of tube wells. The well was a small one made by Ashford on his wire wound principle; it gave ¼ cusec. The outlook was, however, so promising that a larger and deeper well was sunk shortly afterwards which yielded 2 cusecs—a volume of water astonishing at that time. From these beginnings sprang the present practice of tube well engineering.

Tube wells had previously been used in other countries; the Americans employed them for irrigation in the dry zones of California and Texas. It is also of interest to note that tubes wound with horse-hair were in service in Egypt 50 years ago. The fineness of horse-hair and its resistance to corrosion were considered to particularly suit the conditions attending the extraction of water from the sands of the sub-soil. In all probability tube wells have been known for many years, but a systematic study of them with a view to devising improvements has been taken up only recently. In India it was begun within the last 15 years.

Without question, from the agriculturist's point of view, water and moisture are of primary importance. The erratic climate of India with its periods of heavy downpours of rain followed by long periods of dryness renders some auxiliary supply of water imperative. The tube well is by far the most satisfactory means for providing that extra water just when it is most needed. Tube well water costs approximately 2 to 2½ times as much as canal water, but the actual expenditure for water is counterbalanced by the improvement in crops. In some instances, for example, market gardening, the improved returns more than justify the extra cost of water.

With the exception of lands adjacent to large rivers and lands water-logged by the proximity of irrigation canals, the underground water level is maintained solely

by rain. The immense desert tracts of India do not receive enough rain to keep up the sub-soil water within the reach of tube wells. There is, moreover, reason to believe that the supply would fail in such tracts if tapped by very deep wells. The influence of the rivers does, however, extend for miles under the deserts. The underground water levels slope away from 15 feet below ground to 60 feet in a distance of say, 50 miles. Tube well irrigation is economically possible within these strips although no rain worth mentioning falls there. The area of lands adjoining the great rivers of the Punjab is very large, but as yet, little has been done to raise water in these tracts for agricultural purposes, although the conditions are unusually favourable for tube wells.

Irrigation by canals has tended to divert attention from tube wells. Land-owners and cultivators look to Government to provide canal irrigation, instead of themselves taking the initiative, separately or collectively, to make use of the vast underground reservoir which lies beneath their feet. Canal flow irrigation is cheaper than tube well irrigation, volume for volume of water supplied, but canal irrigation is not so convenient. Water from canals is distributed in turns of rigid sequence which may or may not exactly suit the crops, while the owner of a tube well may arrange his irrigation as appears best for his own needs, he is not obliged to wait for the convenience of others. Canal water is, moreover, limited in quantity. In North India the rivers have been drained dry to feed the huge network of canals, and yet the demand for irrigation water remains unsatisfied. The gradual rise of the standard of living coupled with the natural increase of population will inevitably lead to a demand for better methods of cultivation, more water, and more elasticity in its application than is possible with canal irrigation. It is here that tube wells may be regarded as the solution of the problems confronting the future of India in respect of food, fruit and all other products of agriculture. The higher cost of tube well water is no barrier to an extension of agriculture, as will be explained hereafter in detail.

There is one aspect of canal irrigation which bears directly upon tube wells, and that is the menace of water-logging. For the information of readers who may not be in close touch with the adverse side of canal irrigation, it may be explained that canals must be led along the higher parts of the country; they are virtually new rivers of magnitude not much less than the old rivers they replace. Nature's method of draining the country is thus interfered with, and the result is a rise of the underground water level near the canals and large areas of valuable land become marshy and unfit for cultivation, in other words, water-logged, in consequence.

Water logging generally occurs where the sub-soil is porous, where thick beds of sand exist below ground; in fact, those areas wherein tube wells function best are the areas which have become sour and marshy by long continued canal irrigation. A porous sub-soil allows water to rise through it to the ground surface; such soil again parts with its water with equal facility. The causes which produce water-logging are consequently helpful to restoration by tube wells as the latter tend to

lower the sub-soil water level; less than half of the water lifted returns to its source, the balance disappears by evaporation and consumption by plant life.

The cost of tube well water varies in accordance with the depth of the supply below ground; approximately twice the power is required to lift water from 60 feet than from 30 feet. In water-logged areas the average depth of spring level is 7 feet; consequently, the expense for oil fuel or electricity is low, and the general conditions are entirely favourable to irrigation by tube wells.

There is no apparent reason why canal irrigation should not be stopped wherever the sub-soil water is within 12 feet from the surface, and replaced by tube well irrigation. The canal water set free in this manner can be led away to situations where it may be used to advantage on dry lands in need of irrigation. The evil of water-logging will thus be mitigated and an enormous extension of cultivation will result. It is hardly within the scope of this paper to explain how schemes of this order should be engineered. It will be obvious that much power will be required to lift the water from numerous tube wells. The nearest source of power is to be found in the falls on the main irrigation canals, which should be carefully conserved for exploitation in the most economical manner by turbines and electrical distribution to the wells. No temporary and extravagant expedients should be permitted. Every unit of power in the falling water will eventually be wanted to serve the interests of agriculture.

It will be understood from the foregoing that a tube well can only extract water from the earth when the water bearing sands continue to yield water at a rate corresponding to the quantity withdrawn from the well. Desert lands remote from rivers and underground sources of supply, with rainfall less than 10 inches per annum, cannot be watered by tube wells because insufficient water reaches the sub-soil by percolation from above. There is no continuous feed to the sub-soil and any water contained therein is soon exhausted. Our present knowledge of the laws governing the flow of underground water is imperfect, but it is safe to assume that where the rainfall is more than 20 inches a certain number of tube wells may be operated with success, provided they are not spaced so closely as to dry out the sub-soil. The monsoon rainfall over most of India exceeds 20 inches, and a store of water collects below ground during the wet season which may be drawn upon during the dry weather. Water travels very slowly through the sands on its way to lower levels; it does not disperse at once as might be supposed. Heavy local rain creates an elevated mass of water in the sub-soil, sometimes as much as 10 feet above the normal spring level. This circumstance is of importance and reference will be made to it when the engineering side is dealt with in this article.

Although the lower limits of rainfall over areas where tube wells may be used have been approximately indicated, there are many places in India where tube well water is certain to be obtained in quantity. The United Provinces, Bengal, Central India, in fact all districts where the rainfall is copious but not regular, and where geological conditions are suitable, should prove to be excellent for water

supply. The great plains of India have been formed by sedimentary deposits of sand and clay in past ages, and the process still continues. No water can of course be drawn from a clay stratum, but the intervening sands are fully charged with water of incalculable amount. No authenticated case of exhaustion has yet been brought to notice.

The quantity of water it is possible to remove by tube wells from some classes of sub-soil is very great; for example, the writer sank 15 tube wells within an area measuring 4 miles long by one mile wide, from which 27 cusecs of water were drawn up over a period of three years, the actual time the wells were operated being 220 days of 24 hours per annum. The spring level sank 3 feet in the period, but no sign of exhaustion was evident. The area would have yielded water at a still greater rate had more wells been applied to it. To visualize the value of 27 cusecs of water, it may be mentioned that it would suffice to irrigate no less than 7,000 acres of mixed crops, at an average cost of Rs. 10 per acre. The installation in question was planned on modern lines; a canal water-fall near by was harnessed and the water lifted from the wells by electrically driven borehole pumps.

As is the case with most enterprises, the larger the scale on which it is conducted the cheaper the product. This axiom of commercial practice applies to tube well engineering with the same truth as it does to manufactures. The capital cost, supervision expenses, labour, overhead charges, are all lower in relation to the water raised from large groups of wells, than from single wells of small output. These large installations would naturally require to be financed by public companies, Indian States, or by Government, and managed and planned by experts, to ensure the lowest possible cost to the cultivator.

While it is desirable from financial considerations to group tube wells round a central source of power, the impression must not be conveyed that single wells, privately owned, are not profitable investments. On the contrary the assistance given by a tube well to crops depending normally upon rain, often turns what might have been a season of loss into one of profit. The sense of security imparted by the knowledge that all is not lost in times of drought should lead to improvement of agricultural practice and reduce the conservatism so noticeable in India.

Tube wells are fortunately effective in all sizes; it is not necessary to be a rich man to own one. The small well for 10 acres is as reliable as the large 2 cusec well for 500 acres. The illustrations appearing hereafter show types suitable for the irrigation of the smallest plot or the largest estate.

Having traced the general outline of the subject, the technical and engineering details will next be presented.

(To be continued.)

SELECTED ARTICLE

REPORT ON COTTONS FROM SIAM.*

BY

SIR GEORGE WATT.

Report on the botanical specimens of *Gossypium* sent from Siam by Dr. A. F. G. Kerr (from time to time) to me for determination. The references are to "The Wild and Cultivated Cotton Plants of the World."

Gossypium arboreum *Linn.* (typical form).

Ver. name *Fāi Dêng.*

Bangkok, Aug. 1920, *Kerr* 4418

"Flowers, young twigs and petioles, dark purple."

Cultivated as an ornamental shrub only. Common in temple gardens. (*Watt, l.c.*, p. 81, pl. 7-8 : Kew Bull., No. 5, 1926, p. 194.)

Gossypium arboreum *Linn.*

Var. neglectum *Watt*

Ver. name *Fāi Noi.*

Chiengmai, Aug. 1921, *Kerr* L.

Cultivated. (*Watt, l. c.*, p. 95, pl. 10-11 : Kew Bull., No. 5, 1926, p. 195.)

[This has been noted in the Chiengmai district only, but doubtless it occurs elsewhere.]

Gossypium Nanking *Meyen*

Var. siamense, nov.

Ver. names for the form with white floss *Fāi Kāo* or *Fāi Lek* ; for the form with rust coloured floss *Fāi Tun.*

Pāng Hūa Sûa, Chaibādān, *Kerr* 8034 ; Kānburī, Kwê Yai, *Kerr* 10141 ; Kānburī, Tā Kanun, *Kerr* 10270 : Chiengmai, *Kerr* E, P ; Bān Wang Mūang, Rahêng, *Kerr* J ; Lampāng, Hāngsat, *Winit ;* Lampāng, *Winit.*

A very remarkable small bush (1.5 m.), with profusely hirsute foliage and twigs. *Leaves* ovate-rotund, cut into 3-5 lobes with sinuses open and thrown up in folds, obes linear—oblong—deltoid, only very slightly tapering downwards, acute—apiculate ; *Stipules* small linear very caducous, glands 1-3 on the veins ; *Inflorescence*

* Technical and Scientific Supplement to "the Record," No. 2, issued by the Ministry of Commerce and Communications, Bangkok, Siam.

axillary 1-flowered spurs ; *Flowers* small, hardly longer than the bracteoles, yellow with purple claws, not fully expanding and firmly embraced by the erect bracteoles ; *Bracteoles* at first small, linear oblong, scarcely cordate and external glands none but with 3-4 coarse teeth on the apex,— the bracteoles become greatly accrescent (and persistent) around the base of the fruit ; *Fruit* 4-celled, broad ovate-oblong much apiculate, bursting completely open and thus discharging four large compact cobs of seeds which cohere by their involved (almost felted) short coarse woolly floss (much as in *G. arboreum* Linn. var. *assamicum* Watt, *l. c.*, pl. 13.) ; *Seed* large coarse, fuzz and floss strong but firmly adhering and quite useless, except for upholstery purposes or the manufacture of cordage ; *Floss* very woolly and dirty white or rust coloured, one recent sample shows silky floss.

It is said to be cultivated by the Karens as an annual crop. In a letter of Mar. 30th 1926 Dr. Kerr speaks of the plant (10141 and 10270) as being " the common cotton cultivated in the northern parts of the Kānburī Province, near the Burmese border." He then adds that it is only grown in small quantities, however, and for local use. The form (E) is known as *khaki* cotton and is said to often have darker coloured floss than shown in the specimen.

In my report of Aug. 17th 1925, speaking of this plant (8034), I observed " I suspect this may be the original cotton of Siam " a suggestion worth bearing in mind. I now give it a separate varietal name as it is sufficiently distinct to justify recognition, though commercially nearly worthless.

[This variety is the commonest in cultivation in Northern Siam and it extends down on the Western Border to Kānburī Province. The floss seems to vary in quality ; it is commonly used for weaving in N. Siam.]

Gossypium Nanking *Meyen*

Var. **japanense,** nov. in Kew Bull.

Ver. name *Fāi Noi.*

Chiengmai, cultivated, Nov. 1922, a bush (1. 5 m.), *Kerr* A.

A useful plant, should be carefully studied in the production of local supplies. Is the chief source of the better cottons of Japan. (Kew Bull., No. 5, 1926, pp. 196-7.)

[Only occasionally cultivated in the neighbourhood of Chiengmai.]

Gossypium obtusifolium *Roxb.*

Var. ? **Wightianum** race near Kanvi.

Ver. name *Fāī Samut.*

Ubon, Kukan, Hūi Nūa, *Kerr* 8971 : Lôi, Chiengkān, *Kerr* 8974 : Chiengmai, *Kerr* D : Prê, *Kerr* H, K. :

A small plant cultivated in clearings.

In the report of the 17th August 1925, I observed that this is a poor hybrid with only one point in its favour—a high yield of an inferior woolly floss. The mixture

of 8970 with 8971 lowers the value of both : (see *Watt, l. c.*, pp. 143 and 151, pl. 21-22, Kew Bull., No. 5, 1926, p. 205.)

[This variety is also very commonly cultivated in Northern Siam, it is the usual cotton cultivated in the Pre district, and extends into Eastern Siam.]

Gossypium punctatum *Sch. et Thon.*

Var. **nigerium**

Ver. name *Fāi Chan.*

Pāng Hūa Sûa, Chaibādān, *Kerr* 8035.

A straggling cultivated shrub.

This stock may have originally come from America or West Africa, or even from Egypt : it is certainly not indigenous to Siam. It is the plant known in the U. S. A. as the Moque cotton of Arizona, and in Egypt is one of the commonest forms of the so-called Hindi-Weed. It is in most countries a ferine plant but cultivated states of it exist, such as King's Improved, and it is indeed possible that it gave origin to the long series of Short Staples of America —the plant ultimately assuming the form now known as *G. hirsutum* Linn.

Dr. Kerr remarks of this plant " branches purple, flowers pale yellow without dark eyes." " Cultivated 3 or 4 plants, together with a like number of 8034 (*G. Nanking* Meyen var. *siamense*), in a small jungle village." This corresponds to the Indian mixture of *G. hirsutum* with *G. neglectum*, commonly seen in the fields of the Central Provinces—the belief being that the former raises the quality of the latter. As a matter of fact nothing injures a crop of cotton more than the mixture of different lengths of staple. *Watt, l. c.*, pp. 164, 168, 182, pl. 27-8.

[This variety has only been collected once, in the locality noted above.]

Gossypium hirsutum *Linn.*

Ubon, Kukan, Hūi Nūa, *Kerr* 8970 ; Sukōtai, Klawng Tān, *Kerr* 10089.

This was the first plant to attract attention to the Short Staple Cottons of the U. S. A. and even now is a large source of that cotton. The plant is very hairy, the flowers are pale yellow with purple spots, and the seeds are large and coarse. In my report of the 17th Aug. 1925 I wrote " Floss silky and separating easily from the brown-grey fuzz." It is very nearly typical of what in India is called Saw-Ginned Dharwar. (*Watt, l. c.*, pp. 183-200, pl. 29, 30 and 31.)

[Fairly large crops of this cotton are grown in the Sukōtai Province and also south of Ubon.]

Gossypium mexicanum *Tod.*

Ver. names *Fāi Chan* in Ubon Province, *Fāi Samut* in Chiengmai.

Ubon, Chānumān, *Kerr* 8972 ; Chiengmai, *Kerr* C.

One of the chief sources of the better Short Staples or Upland Cottons of the U. S. A.

The sample marked (C) is, in point of foliage, almost typical but the seeds are very nearly naked, showing that the plant is a hybrid, possibly with *G. purpurascens* Poir. It is suggestive of the Durango Cottons. On the other hand the sample No. 8972 is a hybrid that comes near the Sunflower Cottons of the U. S. A. (*Watt, l. c.*, pp. 226-44, pl. 39, 40 and 41.)

[Cultivated rarely in Chiengmai and to a somewhat greater extent on the banks of the Mê Kōng in Ubon Province. Large crops of it are said to be raised on the left bank of the Mê Kōng but the local people say it does not do so well on the right bank.]

Gossypium purpurascens *Poir.*

Ver. name *Fāi Tēt* in Bangkok.

Bangkok, *Marcan* 695 ; Surin, Sangka, *Kerr* 8969 : Bangkok, planted in temple grounds, *Kerr* 10094 ; Chiengmai, *Kerr* B.

Bourbon or Porto Rico cotton, sometimes spoken of as Siam cotton, where it is grown in the temple gardens. A straggling (almost climbing) perennial bush, *twigs* slender angled purplish blistering subglabrous and glaucous. *Leaves* small oblong broader than long, cordate ciliate, when very young, soon becoming glabrous, central vein carries a thick gland, petiole long thin warted by strong dots, blade entire or three lobed, the laterals pointing upwards and outwards ; *Inflorescence* one flowered lateral spurs along the growing shoots ; *Flowers* small pale yellow without purple claws ; *Bracteoles* sub-rotund deeply gashed into linear teeth, the central one the longest ; *Pedicles* terminating in three conspicuous glands ; *Calyx* large loose truncate shortly toothed, the teeth 3-nerved ; *Fruit* small oblong 3-celled ; *Seeds* large smooth nearly naked, wool copious, easily separated, pure white and softly silky.

(B). A somewhat remarkable form, a hybrid approaching *G. mexicanum*, in which the seeds carry a distinct fuzz ; cultivated but not common.

No. 8969. A hybrid with flowers carried along the shoots so as to suggest the name *G. racemosum* ; fruit 4-celled ; seeds with imperfect fuzz. This approaches *G. hirsutum* or *G. mexicanum* according as it is hairy or glabrous. It is a good cotton, especially the glabrous forms ; capable of improvement by careful cultivation and selection of stock. It is possibly the best sample in the present series of Siam cottons and appears to be commonly cultivated in the eastern districts.

To the French colonists is due the once popular position of this species in the production of high-class cottons. The success of the planters of the U. S. A. eclipsed, however, the Bourbon cottons, though for insular countries the subject is well worth re-investigation. It might be suggested that *purpurascens* should be crossed with *brasiliense* in the first attempts, in Siam, to produce improved cotton. (*Watt, l. c.* pp. 250-55, pl. 44.)

[This cotton is commonly cultivated in the southern part of Surin Province but often mixed with other varieties. Elsewhere it has only been seen as an occasional plant.]

Gossypium brasiliense *Macf.*

Ver. names *Samli* in Bangkok, *Fāi Tēt* in E. Siam and Northern Kānburī, *Fāi Lūang* in N. Siam.

Bangkok, Bān Chimbalī, *Eryl Smith* 131 : Bangkok, temple grounds, *Kerr* 10093 : Kānburī, Srīsawat, *Kerr* 10188 : Chiengmai, *Kerr* F., G.

A shrub or small tree (4m.), not systematically cultivated. *Branchlets* round, cuticle blistering ; *Leaves* sharply and acuminately cut into 5-7 lobes the auriculate pair angled (leaves not undulate nor irregular), young foliage tomentose but soon becoming glabrous ; *Stipules* large, more or less persistent ; *Flowers* very large, embraced by the immense bracteoles, glands on the apex of the pedicles large and prominent ; *Fruit* oblong acuminate 3-celled ; *Seeds* distinctly kidneyed, black, naked or nearly so, large oblique oblong, with a tuft of fuzz around the so-called beak.

Kerr 3148, Chiengmai, is perhaps worthy of the position of a variety as the foliage is not typical but better material would be necessary for final determination. Indeed it might even prove a form of *G. peruvianum*.

[This species is not cultivated as a crop but occasional plants are quite common in village gardens.]

Gossypium brasiliense *Macf.*

Var. **apospermum** *Sprague*, Kew Bull., 1914, pp. 198-199.

The Cauto Cotton of south-east Cuba.

Ver. name *Fāi Lūang*.

Chiengmai, *Kerr* 10087.

Attention was first drawn to this plant by Mr. W. Harris, Supt. of Public Gardens and Plantations in Jamaica. He speaks of it as a tree cotton apparently found wild or semi-wild and tells us that it is a perennial likely to prove of considerable value for cultivation in dry districts within the tropics. Mr. Harris further observes that it is estimated to yield at least 1200 lb. of seed-cotton per acre and since the *wool* has been sold at prices varying from 18-20 cents per lb., in the American market, the plant gives promise of being of considerable value.

Sprague, who published an account of the plant in the *Kew Bulletin*, giving it the above-mentioned provisional name *apospermum*, says that it agrees, in most of the technical characters, with *G. brasiliense*, from which it differs in the seeds being free from one another ; he then remarks that in view of its being wild or semi-wild it may possibly " represent the wild stock " of that species but he adds that " the possibility of its being a hybrid of *G. brasiliense* with some other species cannot be entirely excluded."

A specimen was sent to me from Siam, in 1925, by Dr. A. F. G. Kerr (No. 10087) which, not having then seen the Cuban plant, I identified as possibly *G. peruvianum* but the material was not satisfactory and I asked for further supplies to enable me to finally determine the plant. In consequence additional specimens have now come

to hand and I find that it matches in every detail Mr. Harris's Cuban plant, even to the seedlings, which in both sets have been supplied. In my mind there is little or no doubt that the plant is a hybrid of *G. peruvianum* × *brasiliense*. It is, therefore, a matter of little importance under which species it is placed, except that the seeds of *peruvianum* are normally apospermous. I am disposed to think it may be a recessive hybrid which in its present manifestation shows the strongest strain of *peruvianum*. But it is singular that there would appear to be no form of *peruvianum* proper in Siam and further that this remarkable hybrid should appear spontaneously in two so remote and so very dissimilar countries, with hardly any trace of it in the intermediate regions. I am in fact confirmed in the opinion, reported to Dr. Kerr in 1925, that its strongest affinity is with the *Met afifi* cottons of Egypt. But Mr. D. N. Simpson has supplied me with plants under the so-called Hindi-Weed of Egypt that approximate very closely to the Cauto cotton, an opinion that makes me the more suspicious of the dominancy or permanency of the plant. It would be interesting to learn from Jamaica of the success that has been attained in the endeavour to make Cauto cotton of commercial value.

The following specimens may be recorded as being *var. apospermum* Sprague :— Harris's Cauto plant, grown in the Hope Gardens, Jamaica, (4th May 1914), also the Cuba plant, (31st Mar. 1914) : Dr. Kerr's Siamese specimens, No. 10087 : also (R), Bangkok, a specimen showing the seeds free but with a rusty tuft around the beak ; and (M), Chiengmai, seedlings.

Cultivated in Siam but not as a crop—a perennial shrub or small tree. The foliage is striking and may be examined as follows :—

(*a*) *Cotyledons and first leaves of seedling*—transversely elliptic (twice as broad as long), entire, obtuse, but not at all cordate, 3-5 veined and veins winged and forming a web-footed attachment to the winged petiole, 1-3 veins of the first leaves may carry small linear glands near the base, and foliage quite glabrous but prominently punctated, with black dots.

(*b*) *Early leaves*—broad ovate, entire acuminate or apiculate, becoming faintly cordate, 3-5 veined and winged, as already described, when young with minute stellate hairs but turning quite glabrous, and stipules narrow linear early caducous.

(*c*) *Later leaves*—cordate, 3-toothed on the apex, as in *G. mexicanum*, teeth broad deltoid acuminate, central one much the longest, petiole and young shoots winged and web-footed, within the cordature.

(*d*) *Ultimate leaves*—much as in *G. peruvianum*, very large coarsely-formed (not cut sharply and uniformly as in *brasiliense*) 5-7 lobed, bottom short pair pedate and lobes sometimes conspicuously toothed on the margin, blade from apex of the petiole to tip of central lobe 8-10 ins. and across from tip to tip, 10-15 ins., veins imperfectly winged but prominently web-footed and carry 1-3 glands that look like slits, with a tongue of epidermis within, veins and reticulations prominent, pale coloured

deeply auricled (the auricles overlapping the petiole) and the whole surface quite glabrous (except on the veins below where a few stellate hairs may be seen), petiole round but showing lines representing the wings and prominently gland-dotted, petiole 1-5 ins. long.

Twigs and shoots—rounded or only faintly angled, quite glabrous, minutely gland-dotted, brown flushing purple: *Inflorescence* axillary spurs which carry 2-3 extra axillary flowers; *Bracteoles* ovate rotund, free, or nearly so, deeply gashed into 15-20 long much-awled nearly equal teeth, the central one again gashed into 3 but not abnormally elongated and quite glabrous, not maculate as in *brasiliense* but fully half the length of the corolla which is lemon-yellow streaked with purple (as it matures); *Glands* on the apex of the pedicle not very prominent, pedicles furrowed and angled; *Calyx* a loose cup cut square across; *Capsules* ovate acute (not elongate acuminate as in *brasiliense*), almost entirely embraced by the accrescent and persistent bracteoles; *Seeds* free, black, with a rufous tuft of fuzz around the beak, obliquely striated, the furrows giving attachment to the floss.

[Unfortunately at the time of collection this was not recognized as a distinct variety; it does not appear to be common. It is hoped to get more information about this interesting plant.]

July 5th, 1926. GEORGE WATT.

[To the above report have been added more detailed localities and also some local names. The notes in square brackets are also additional. Not much reliance can be placed on the local names as the cultivators themselves often do not distinguish between different varieties. A. K.]

NOTE.—Since this report was put in type, Mr. M. S. Goodman, Superintendent of Public Gardens and Plantations, Jamaica, has written as follows :—" The Cauto cotton was tried here but the conditions of climate and seasons are so erratic that cotton cultivation is one of the most speculative and uncertain of agricultural enterprises ever attempted in Jamaica. During the seasons that were suitable to cotton growing the Cauto cotton gave good results but the price offered for the cotton was so low that it would not pay to cultivate it and its cultivation has been discontinued."

NOTES

ISOLATION OF PATHOGENES FROM DISEASED MATERIAL.

The Secretary, Indian Central Cotton Committee, has sent the following abstract for publication :—

THE following point in mycological technique has been discussed with several mycologists from time to time and some of them have since used it with success. It may be found to save trouble to workers who may have to isolate their fungi in draughty rooms and particularly in tropical countries where accommodation and equipment is not always all that can be desired.

In making isolations of pathogenes from diseased material, the usual procedure may be briefly described as follows :—Some of the spores, tiny pieces of the diseased material, or fragments of mycelium are placed in sterilized water in a test-tube or in a drop of sterile water on a flamed slide. A platinum loop is then flamed and a loop full of the water with spores or material in suspension is transferred into a test-tube containing melted agar at the required temperature and mixed. The melted agar with spores in suspension is then poured into a sterilized Petri dish. Subcultures are then made later from the colonies produced in the Petri dish. It is often the case, however, that quick growing fungus weeds and bacteria are very troublesome and seriously contaminate the Petri dish cultures. This can frequently be avoided by allowing the agar in the test-tube to cool to a point so that, after pouring into the Petri dish, sufficient agar will be left in the test-tube to form a thin coating round the sides of the test-tube. If, in addition to the Petri dish, the test-tube is also retained, subcultures can almost always be made from tiny colonies on the film of medium round the test-tube. This film is not exposed to contamination to the same extent as the Petri dish. Additional advantages over the Petri dish is derived from the fact that the medium is in the form of a thin film. The growth of the colonies is not so rapid that they grow into one another quickly, and incidentally the colonies on the thin film of medium often produce spores in a shorter time than in the thicker and moister medium in the Petri dish. Preliminary examination with a lens also assists in spotting the common weeds since these can often be recognized by their method of growth at a very early stage. Further, the colonies in the test-tube can be examined on several occasions without fear of further contamination, whereas with the Petri dish there is danger each time the lid is tilted. Lastly, a Petri dish on cooling sucks in air and with it fungus spores and bacteria.

When an inoculating chamber is used for culture work, it is often desirable to free it of fungus spores and bacteria. For this purpose commercial formalin is

often used, but there is the serious objection that several days must pass before one can enter and work in the cabinet owing to the discomfort caused by formalin vapour. It has been found that it is not necessary to sterilize the chamber to avoid contamination. All that need be done is to boil some water and allow the steam to condense. The condensed moisture on the sides of the chamber holds down bacteria and fungus spores very effectively. It need hardly be pointed out that the effectiveness of the operation ceases as soon as the chamber becomes dry. [H. R. BRITON-JONES. *Tropical Agriculture*, Vol. IV, No. 5, May 1927.]

THE TWO MOST COMMON DECAYS OF COTTON BOLLS IN THE SOUTH-WEST STATES.

The Secretary, Indian Central Cotton Committee, has sent the following abstract for publication :—

Two forms of decay of cotton bolls, frequently referred to as "smut" in their later stages, have been found to occur commonly in southwestern United States.

These diseases are not true smuts and have only a superficial resemblance to the smuts.

One of these forms of decay is caused by *Aspergillus nigar Van* Tiegh and the other by *Rhizopus nigricans* Ehr.

The two diseases may be readily distinguished by the discoloration of the affected tissues as well as by the character of the fruiting stages of the parasites.

Both organisms readily produced rot of artificially wounded and inoculated cotton bolls, but failed to affect uninjured bolls.

The infection in the field apparently depends on injuries caused by various insects, the most noticeable of which are those caused by the boll-worm. Control measures, therefore, will have to be directed chiefly against these insect enemies. [*Jour. Agri. Res.*, Vol. 35, No. 4. MICHAEL SHAPOVALOV.]

EFFECT OF HYDROGEN-ION CONCENTRATION ON THE ABSORPTION OF PHOSPHORUS AND POTASSIUM BY WHEAT SEEDLINGS.

The Secretary, Indian Central Cotton Committee, has sent the following abstract for publication :—

Wheat seedlings were grown in potassium phosphate solutions of different initial hydrogen-ion concentrations.

Relatively more potassium than phosphorus was absorbed by the seedlings, irrespective of the initial hydrogen-ion concentration of the solution. In the solutions with initial hydorgen-ion concentrations of 5·0 and lower, this preferential

absorption of potassium resulted in increased acidity. In solutions with initial hydrogen-ion concentrations of 6·0 and 7·0, the increase in acidity was but slight, owing to the buffer properties of the solutions.

More phosphorus was absorbed by the se dlings from the solutions with initial p^H values of 5·0 and lower than from those with p^H values of 6·0 and 7·0. As all potassium salts of phosphoric acid are soluble, this tends to show that the physiological availability of phosphorus depends upon the hydrogen-ion concentration of the medium.

The general character of the results was not affected by the duration of the experiments nor by the age of seedlings. Neither was it affected by the concentration of the solution, provided the differences in initial reactions in the solutions of the lower concentrations were maintained by daily renewal.

The excess of phosphorus absorbed from the acid solutions was found in the tops of the seedlings. The tops also had a higher potassium content than those from the neutral solutions. The roots from the neutral solutions contained more phosphorus and almost twice as much potassium as those from the corresponding acid solutions.

The power of the seedlings to absorb phosphorus and potassium decreased as they advanced in age.

The absorption phenomena observed in these experiments, as well as the absorption of cations and anions by living cells in general, are explained by the assumption that there is a relatively wide range in the isoelectric points of individual protoplasmic ampholytes. [*Jour. Agri. Res.*, Vol. 35, No. 4. JEHIEL DAVIDSON.]

RURAL UPLIFT IN THE INDORE STATE.

IMPORTANT developments relating to the uplift of the countryside are in progress in Indore State. In 1927, the Darbar decided to deal with rural uplift as one subject and to create a Department of Rural Development in charge of a senior officer. With this object the work in progress in Agriculture and Co-operation was amalgamated into a single agency. It is proposed, as time goes on, to extend the Department of Rural Development still further and to include in it most of the existing organizations which now deal with the cultivator.

The new Department has made a good beginning and has begun to utilize the results obtained at the Institute of Plant Industry which serves as the central experiment station for the new scheme. Further developments are in progress. The Darbar has decided to pass the whole of the Revenue staff through the Institute of Plant Industry and for this purpose is erecting a hostel on the area leased to the Institute. In addition, plans and estimates are being prepared for a large cattle farm near Indore for the improvement of the Malwi breed of work cattle. [From *Capital*, Vol. LXXX, April 12, 1928.]

SUPPLY OF SUGARCANE VARIETIES FROM THE IMPERIAL SUGARCANE STATION, COIMBATORE.

INDENTS for planting material of sugarcane varieties are received from correspondents practically all throughout the year with the result that, in the past, a certain number of them had to go disappointed. This note is written with a view to helping such correspondents.

The bulk of the sugarcane crop at the Imperial Sugarcane Station at Coimbatore is harvested between February and April; and all material, before it is sent out for planting, is invariably examined and passed for fungus diseases and insect pests by the Government Mycologist and the Government Entomologist, respectively, at the Agricultural College, Coimbatore. Indents for sugarcane varieties should therefore reach the undersigned by the middle of January at the latest. As the material available at the station is rather limited, partly because of the very large number of varieties and seedlings that have to be grown each year and partly because of the need to meet indents from all over India and Burma, it is not generally possible to send out, of any variety, more than a limited quantity —say about half a dozen pieces, each four feet long.

It may be mentioned here that it is best to obtain a new cane for trial in a small consignment in the first instance for the following reasons :—

(1) Large cane consignments not only involve heavy transport charges but give a comparatively poorer germination at destination, because the buds or 'eyes' are likely to get damaged in transit. It is easier to send out a smaller consignment taking the necessary precautions against such damage.

(2) New canes take some time to get acclimatized in a locality with the result that a larger consignment does not generally result in a proportionately larger number of plants during the first year.

(3) It is safer to multiply gradually one's crop from a small lot of carefully selected disease-free material than from a big one which is at all suspicious in this respect; and the smaller the consignment the greater the chance of its being "safe" material. The damage to cane crops from insect and fungus pests is so great and methods of control so difficult and expensive that a grower cannot be too careful in this matter.

(4) Once a cane is really found suitable in a tract, it is now possible to multiply rapidly the same in a short period by a process which has been in vogue in Java and recently fully described by Mr. Wynne Sayer in the *Agricultural Journal of India*, Vol. XX, Part 2, page 148.

Correspondents are also requested to apply in the first instance to the Provincial Agricultural Departments before writing to Coimbatore for cane material. The Provincial Departments of Agriculture grow on their farms, sometimes, fairly large quantities of the more popular of the Coimbatore seedlings; and such a supply, besides the obvious saving in freight charges, would secure for the correspondents material to some extent acclimatized to the province. [RAO BAHADUR T. S. VENKATRAMAN, Government Sugarcane Expert, Lawley Road Post, *viâ* Coimbatore.]

WOODHOUSE MEMORIAL PRIZE.

AMENDED RULES.

THE Prize will be in the form of a silver medal and books of a combined value of Rs. 85 to be competed for annually under the following conditions :—

The competition is open to graduates of Indian Universities and to Diploma holders and Licentiates of recognized Agricultural Colleges in India who are not more than 30 years of age on the date of submission of their essays.

The prize will be awarded to the writer of the best essay on a subject of botanical interest, to be selected from a list which will be drawn up each year by the examiners and published with an official notice regarding the competition in "The Agricultural Journal of India." Notices will also be sent to Departments of Agriculture and Universities in India.

The length of the essay should not exceed 4,000 words; and the prize essay, if of sufficient merit, will be published in "The Agricultural Journal of India." It must not be published otherwise without the sanction of the Director of Agriculture, Bihar and Orissa.

The examiners will be :—

(1) The Imperial Economic Botanist, Pusa.
(2) The Economic Botanist, Sabour.
(3) A Botanist attached to a provincial Agricultural Department, who will be selected by the Trustees each year.
(4) A leading Botanist of an Indian University.

If no essay is sufficiently good, the prize will be held over and the money will go to increase the fund.

LIST OF SUBJECTS FOR 1928 PRIZE.

1. Modern methods of crop improvement by botanical methods.
2. The application of cytology to plant breeding.
3. The place of physiological research in botanical science, as applied to crop improvement.
4. The importance of lower organisms to the growth of plants.
5. The technique of yield trials with special reference to Indian crops.
6. The problem of sterility in Indian crops and fruit trees.

Papers should be forwarded to the Director of Agriculture, Bihar and Orissa, Sabour, Bhagalpur, E. I. R. Loop, before November 1st, 1928.

Personal Notes, Appointments and Transfers, Meetings and Conferences, etc.

We have heard with deep regret of the death on the 16th July, 1928, of Sir FRANK GEORGE SLY, K.C.S.I., D. Litt., late Governor of the Central Provinces. He served as Inspector-General of Agriculture in India from December 1904 till February 1907, and it was during these years, the foundations of the Indian Agricultural Departments were firmly and wisely laid.

MR. T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S., Imperial Entomologist, was on leave on average pay for four months with effect from 4th May, 1928.

MR. P. V. ISAAC, B.A., D.I.C., M.Sc., F.E.S., Second Entomologist (Dipterist), officiated as Imperial Entomologist, *vice* Mr. T. BAINBRIGGE FLETCHER granted leave.

Rai Bahadur C. S. MISRA, B.A., First Assistant to the Imperial Entomologist, held charge of the current duties of the post of Second Entomologist (Dipterist), in addition to his own, *vice* Mr. P. V. ISAAC appointed to officiate as Imperial Entomologist, Pusa, from the 4th May, 1928.

Consequent on the retirement of Mr. D. A. D. AITCHISON, M.R.C.V.S., Mr. F. WARE, F.R.C.V.S., has been confirmed in the appointment of Veterinary Adviser to the Government of Madras.

It has been decided by the Punjab Government (Ministry of Agriculture) that in future both Branches of Veterinary Administration, namely, cattle breeding and the prevention and cure of diseases of animals, shall be under the control of

a Director of the Civil Veterinary Department, who will be the Head of the Department.

In accordance with the above decision, a post of Director, Civil Veterinary Department, has been created with effect from the 4th of July 1928 and with effect from the same date the post of Chief Superintendent of Civil Veterinary Service has ceased to exist.

MR. T. F. QUIRKE, G.V.S., has been appointed Director of the Civil Veterinary Department, Punjab, with effect from the 4th of July 1928.

MR. G. S. GAREWAL, M.R.C.V.S., has been appointed Live Stock Officer to Government, Punjab, with effect from 26th July, 1928.

MR. N. V. KANTIKAR, Assistant Professor of Chemistry, has been appointed to do duty as Soil Physicist to Government, Bombay, *vice* MR. V. A. TAMHANE.

REVIEW.

Land Tenure and Agricultural Production in the Tropics.—By H. Martin Leake, Sc.D. Pp. x+139 (Cambridge: W. Heffer & Sons.) Price, 7*s.* 6*d.* net.

Dr. Martin Leake's latest book entitled "Land Tenure and Agricultural Production in the Tropics" is not one to be read in a single sitting. Like all Dr. Leake's works it requires careful study. It is a very thoughtful and erudite treaties on the important subject of agricultural land tenure. Dr. Leake's long experience of India enables him to draw lessons from the ancient systems found in India. He is specially conversant with the talukdari system of Oudh and U. P. generally. He has divided his subject into six chapters, and has given some of his own articles bearing on the subject as appendices. Dr. Leake starts with a discussion of the theoretical aspect of land holding. In the second chapter he gives a sketch of the Indian systems based on Akbar's revenue system which fixed the revenue assessment at 90 per cent. of the assets on the following basis:—

"There shall be left for every man who cultivates his land as much as he requires for his own support till the next crop is reaped and for that of his family and for seed. This much shall be left him, what remains is land revenue and should go to the public treasury."

Tropical development and the agencies of development are dealt with in the next two chapters. The author then goes on a discussion of the policy which he thinks will meet the situation and make for progress and development. This he calls the "Triple Partnership", (1) The Raj, (2) The Zemindar, (3) The Cultivator.

In the last chapter the author deals with the educational problem. On this subject Dr. Leake is very much at home as he was head of the Agricultural College, Cawnpore, for a number of years, and he is thus in a position to give first hand information. He points out the necessity of giving a proper technical training and education to the people who can take advantage of it; for example, zemindars and sons of zemindars and those with vested interests in the land are the proper people to be educated at agricultural colleges. On the contrary, what is frequently done is to give training to a class of men who carry no weight in the land and who are unable to make any use of their training. They expect to be supported while under training and be put in Government service when the training is finished.

Dr. Leake's book should be valuable to administrators in charge of tropical areas in various parts of the world, such as Africa, which are being rapidly opened up for the cultivation of crops such as cotton, tobacco, cocoa, rubber, tea, etc. [G. S. H.]

CORRESPONDENCE

VARIABILITY IN THE GINNING PERCENTAGES IN CROSSES OF INDIAN COTTONS.

To

The Editor, *The Agricultural Journal of India.*

Sir,

THE explanation suggested by Mr. Kottur,[1] for the occurrence of variation in the ginning percentages in one of the series of figures of F_8 given in Table 1 of my note on "Variability in the ginning percentages in crosses of Indian cottons"[2], appears to be based on the assumption that the ginning percentage like other allelomorphic characters is a simple unit character, and that its variations could be accounted for by an interpretation of results after ordinary laws of inheritance. On the other hand, the ginning percentage is found to be a very complex figure determined by so many independently variable factors, which contribute to the ultimate product known as ginning percentage, which is a symbol only indicating a particular phase of variation in the proportion of lint to seed in the un-ginned cotton. To assume that all the component factors of the ginning percentage uniformly vary in their successive generations, and therefore are within the range of interpretation like other definitely defined characters, is more than what can be warranted by our present information on the subject.

Mr. Kottur suggests that the gradual increase by selection in a low ginning strain "can only be explained" by natural crossing. In Table III of the same note we find that a cross whose parents were 32 and 45, gave offsprings ginning 24 and 47, indicating that the range of variation can exceed both ways. The number of causes which influence the modification of the factors composing the ginning percentage and the extent of their operation severally on the component elements, are matters which are still obscure. Mr. Kottur's explanation, therefore, could be one of the many possibilities, had we not met with the values falling lower than those of both the parents in another set of figures given in the same note. The ginning figures in later generations appear to be spreading beyond the range of their parental values, and either of such extremes, if isolated and taken further by selection, are known to produce better results on an average. Whether they are

[1] *Agri. Jour. India*, Vol. XXII, Pt. 1, p. 70.
[2] *Agri. Jour. India*, Vol. XXII, Pt. 1, pp. 23—29.

due to the causes unknown at present or to an intrusion of foreign influences alone, as Mr. Kottur suggests, is more than what could be definitely affirmed at this stage. The object of the note under reference was to place on record a description of the variations found, rather than an explanation of the causes, which are still under investigation.

Yours faithfully,

RAMA PRASADA,

Asstt. Economic Botanist to Government,
United Provinces (Working on Cotton).

NEW BOOKS.

On Agriculture and Allied Subjects.

1. The Evolution and Classification of Soils, by the late Dr. E. Raman. Translated by G. L. Whittles, M.A., Ph.D. (Cantab.), Cambridge; W. Heffer and Sons Ltd. 7/6 net.
2. Soil Culture and Modern Farm Methods (Fourth Edition), by Dr. W. E. Taylor, Deere Company, Moline, Illinois, U.S.A.
3. Imperial Agricultural Research Conference, 1927: Report and Summary of Proceedings published by His Majesty's Stationery Office, London. Price 1*s.* (with postage 1*s.* 5*d.*).
4. Rural Education in England and the Punjab, by R. Sanderson, M.A., I.E.S., and J. E. Parkinson, M.A., I.E.S. (Education, India: Occasional Reports No. 15). Calcutta: Government of India Central Publication Branch. Price, As. 12 or 1*s.* 3*d.*

The following publications have been issued by the Imperial Department of Agriculture in India since our last issue :—

Memoirs.

1. Studies in the shedding of Mango Flowers and Fruits, Part I, by P. B. Wagle, M.Ag., (Botanical Series, Vol. XV, No. 8). Price, As. 11 or 1*s.* 3*d.*
2. The Composition of Indian Rain and Dew, by J. Walter Leather, Ph.D. (Reprinted). (Chemical Series, Vol. I, No. 1). Price, As. 5 or 6*d.*
3. The Composition of the Oilseeds of India, by J. Walter Leather, Ph.D. (Reprinted). (Chemical Series, Vol. I, No. 2). Price, As. 12 or 1*s.* 3*d.*
4. Some Digestibility Trials on Indian Feeding Stuffs, III: Some Punjab Hays, by P. E. Lander, M.A., D.Sc., A.I.C. and Pandit Lal Chand Dharmani, L.Ag., B.Sc. (Ag.). (Chemical Memoir, Vol. IX, No. 7). Price, As. 5 or 6*d.*
5. The Determination of the Electrical Conductivity of the Aqueous Extract of Soil as a rapid means of detecting its probable fertility, by Ashutosh Sen. (Chemical Series, Vol. IX, No. 8). Price, As. 4 or 6*d.*
6. Studies on *Platyedra gossypiella* Saunders (Pink Bollworm) in the Punjab, by Sohan Singh Bindra, M.Sc. (Entomological Series, Vol. X, No. 6). Price, Re. 1-4 or 2*s.* 3*d.*

Bulletins.

7. A comparative study of the methods of preparation of the soil for the mechanical analysis with a note on the Pippette method, by Amarnath Puri, Ph.D. and B. M. Amin, B.A. (Bulletin No. 175). Price, As. 4 or 5*d.*
8. Root-rot and Sclerotial Diseases of Wheat, by L. S. Subramanium. (Bulletin No. 177). Price, As. 4 or 5*d.*

MGIPC—M—III-1-78—1-10-28—1,670.

ORIGINAL ARTICLES

NOTES MADE ON A TOUR IN EGYPT.

BY

SIR THOMAS MIDDLETON, K.B.E., C.B.,

H. C. CALVERT, C.I.E., I.C.S.,

AND

N. GANGULEE, PH.D., B.Sc.

Members of the Royal Commission on Agriculture in India.

(Concluded from Vol. XXIII, Pt. V.)

IRRIGATION.

SOME of the main features of Egyptian irrigation were explained to us by officers of the Public Works Department. We visited the Hydrological Section of the Ministry at Cairo, which is concerned with the measurement of the flow of water in the Nile, and the making of forecasts for the information of irrigation engineers. A large number of depth guages have been established in the Nile throughout the Sudan, and at these points the rate of flow of the current is determined by specially constructed meters which register the rate automatically. At any one cross-section of the river the rate of current is measured at 25 points; the exact position of the meter in the river is determined by angular measurement. As a check on this method of estimating the volume of water carried by the river, direct measurements have been made in a large tank constructed at the Assouan Dam, and the results given by the meters and direct measurement have proved to be almost identical. The amount of water carried by the Nile down stream from the Assouan Dam varies from about 750 cubic metres per second in the dry months, March, April and May, to 8,000 cubic metres in September.* The average flow for the year is 2,630 cubic metres. After the month of December very accurate forecasts of the probable flow of the Nile until the following May can be prepared.

The Meteorological Service of Egypt forms a section of the Ministry of Public Works. It has a meteorological observing station of the first order at Helowan, 10 'second order' stations, and a number of 'third order' observation stations. A daily weather report and other meteorological publications of the usual type are prepared in this office.

* This is roughly 250,000 cusecs, or one-fourth of the volume carried by the flooded Indus.

Having seen the methods adopted in measuring the Nile flow, we went by river steamer to see the Delta barrage erected at the point where the Nile bifurcates into the Rosetta and Damietta branches. This barrage, from which six large canals take off, regulates the flow of water over the entire Delta. At Assyut, 400 kilometres south of Cairo, there is a second barrage which controls summer and low flood water and commands the Ibrahimiya Canal, the main canal irrigating the western side of the Nile valley above Cairo, and also supplying water to the Faiyum. A third Nile barrage is located at Isna, 170 kilometres north of the Assouan Dam.

Besides the canals originating at the barrages, there are, in Egypt, a number of canals taking off direct from the river and feeding the basin systems of irrigation both east and west of the Nile. Basin irrigation was the ancient irrigational method of Egypt, but it is now rapidly being replaced by the perennial flow system. There are, however, about 1,200,000 feddans still under basin irrigation. Basins, which may be many square miles in area, are bounded by embankments; the cultivators holding land within the basin are notified that on a given date water will be let in, and that the crops then on the land are there at their risk; they are not always able to harvest all their crops before flooding starts, and cotton, etc., may sometimes be seen in flooded tracts. After flooding, the land remains under water for a month or two and when the Nile has fallen, it is drained and sown with winter crops. As a rule, basin irrigated land can grow but one crop in the year; but by means of water lifts, a good deal of it is watered early in the season and two crops are then secured.

At the delta barrage the Irrigation Department maintains an experimental station; tanks are provided in which the flow of water through sluices and channels can be studied experimentally. Investigations are now in progress with the view of devising suitable modules. By one ingenious device, recently invented, any given volume of water desired can be delivered into a canal with accuracy. There is a museum containing models of structures and devices connected with Nile irrigation, in which reproductions of the Assouan Dam and other important irrigation works may be examined.

Ordinance Survey.

Much attention is given to the survey of Egypt, as it provides a basis for land taxation. The department is a large one, and is well equipped for its work. At the time of our visit, it was occupied in a special cotton survey. As above noted, an Act has recently been passed restricting the area under cotton to one-third of the total cultivated area. Returns are collected from village headmen and, where there is any suspicion that these returns are incorrect, or that the area exceeds the amount allowed by law, the survey makes special measurements. In only a small percentage of cases were such special surveys held to be necessary. The cost of administering this law must, however, be considerable.

A new atlas of Egypt is now being prepared and we had an opportunity of inspecting some fine colour printing in interesting special maps. The photographic

department attached to the survey includes in its work the production of Egyptian postage stamps.

GUIMEZA EXPERIMENTAL FARM.

After seeing the offices of the Ministry and the institutions located at Cairo, we visited one of its chief experimental farms situated near Tanta in the Delta. The main objects of this farm are : (1) to grow, on a considerable scale, the new varieties of cotton raised by the Botanical Department of the Ministry at their laboratories in Giza ; (2) to conduct manurial and other experiments ; (3) to improve breeds of livestock. The farm is a large one of nearly 1,400 acres ; it employs in all about 350 labourers and has 140 working animals, mostly oxen. The soil is of three qualities : heavy, light and medium loam. It has been carefully reclaimed and levelled and the whole property is in a high state of cultivation. The crops which we saw growing were remarkably fine. The chief kinds of seed sold from the farm are wheat, cotton and maize. Of wheat the quantity may vary from about 250 to 700 ardebs of 150 kilos, cotton from 500 to 700 ardebs of 120 kilos, and maize from 300 to 500 ardebs of 140 kilos. Especial attention is concentrated on the seed of cotton ; the crops are carefully rogued and the produce is picked over by children, to ensure that damaged and imperfect seeds are excluded.

The field experiments bear on such subjects as varieties of cotton and other crops, the best time for applying water, and the effects of manures. The soil being rich, the effects of manure are not marked, but the influence of varying the water supply, and changing the date of application, was readily seen on the growing crop. The experimental plots are laid down very carefully in checkerboard fashion ; the usual size of plot is about one-tenth feddan. These plots are repeated up to six times. In the case of cotton the seed is deposited on ridges 35 centimetres between the plants and about 80 centimetres between the rows. As on the other farms in the delta, great attention is given to the levelling of the land ; it is partly levelled under water, and partly when dry. The implements employed on the farm are nearly all of the indigenous type. Occasionally a tractor with one-way iron plough is used ; nearly all the work is done by the wooden plough much resembling the Indian implement except that the share is spoon shaped, as it works in soft soil which does not require a sharp point. Attention has been given to the possibility of improving the implements, but we were informed that the representative of an English manufacturer, who had visited the country and spent some time in examining the work of the native plough, had expressed the opinion that he could not improve upon it (no doubt at the price at which the competing implement would have to be sold in Egypt) and this view seems to be concurred in by those in charge of the farm. The most interesting implement we saw was a small thresher fitted with three to four discs like those of the disc harrow or plough, but not so sharp. This is pulled round the threshing floor and both beat out the grain and crushes the straw. It has been used from time immemorial in Egypt. For levelling land under water a

12 to 14 foot plank similar to the implement used for levelling land in India is employed, but it has got a steel or iron plate fixed in front and is furnished with a handle like the plough. For levelling dry land, a small wooden scoop about 2 ft. 6 in. wide is the standard implement employed. All the implements were very simple, but they did their work thoroughly well; the land was uniformly well cultivated and remarkably free from weeds.

In the breeding section the main animals kept belonged to two breeds: the Belladi, or ordinary Egyptian, and the Damietta. There are about 50 cows of the former breed and 20 of the latter. The Damietta breed differs from the Egyptian in being smaller, usually rather lighter in colour (the colour is that of the South Devon breed) and in giving much more milk. It appears to have originated in the neighbourhood round Port Said after the opening of the Suez Canal; a demand for milk then arose in this quarter and cows were selected for their milking quality. The ordinary Egyptian breed is essentially a draught breed; the frame is long and carries no superfluous flesh, the tailhead is abnormally high as compared with European or Indian cattle. This high tailhead is liked by the Egyptians. The usual colour is red or light red, but occasionally spotted animals are seen. In general the cattle may be described as good draught animals, active and hardy. We saw many fewer of them than we should have liked, but from the information given us, it would seem that the Egyptian fellah treats his cattle better than the Indian cultivator. At no period of the year are they subjected to prolonged starvation; the Egyptian fellah does not keep a single useless animal, and the total number of cattle in the country is no more than is absolutely necessary for the cultivation of the land. The cattle are much less seen on the roads in carts than in India, since much of the transport is done by donkeys.

THE STATE DOMAINS.

These extensive properties, of which the headquarters are in Cairo, and the central offices of the land farmed are at Sakha in the centre of the Delta, play an important part in the improvement of Egyptian agriculture, as the whole area available for cotton growing is devoted to the production of pure seed for distribution. When Egypt got into financial difficulties, the ruling family ceded about 425,000 feddans of land to the State as a guarantee for a loan of £8,500,000 advanced by Messrs. Rothschild in 1878. A mixed Commission was appointed to control this area. Gradually the debt was extinguished, and in 1913, part of the land having in the meantime been sold, an area of about 140,000 feddans was handed back to the Egyptian Government, who established a State Domains Administration to control it and other State lands. This administration now has under its charge about 1,500,000 feddans, in addition to town property; but most of this land is still unreclaimed. The total area of reclaimed land is about 65,000 feddans, and of this area some 35,000 acres are farmed directly by the Administration under the

charge of resident inspectors. The Domains are split up into blocks of from 8 to 10,000 feddans, each under the charge of an inspector. We drove over a large part of two of these blocks, or *Teftishes*; they consisted of a very highly farmed tract of land, of a quality that must be rare in any countries. The blocks are divided into estates of 1,000 to 1,500 feddans under the charge of a sub-inspector who is assisted by an accounts clerk and bailiffs. The farms are divided into great fields of from 100 to 120 feddans. These fields are surrounded by earth roads which in the Egyptian climate are easily maintained; on one side of the road is an irrigation channel, on the other side a drain. All reclaimed land has been perfectly levelled and the crops growing on them were as uniform in quality as one usually sees on a garden patch of a few acres. This result was accomplished, in the case of cotton, not only by tillage of a very high order, but by a careful system of bulk seed selection. While the State farm at Guimeza undertakes the task of growing new varieties of cotton and testing them thoroughly, the State Domains Administration have made it their business to supply in large quantities pure strains of seed of the best variety. Generally in the Delta in recent years Sakellarides has been the variety selected. The pure seed is consigned to the Ministry who distribute it throughout the country. Some time ago a stock of the best Sakel seed available was secured; on growing it was found to be very mixed; it was carefully rogued until approximately pure, and its quality is now maintained by the following process of bulk selection, introduced by Mr. Jeffreys, a former manager of the Domains. When the first cotton is ripening, groups of children, who have been carefully trained, are sent out with orders to pick cotton of a certain colour and type. They become expert at the work, and the result is that seed of the desired type of Sakel is secured. This picked seed is next ginned; the seeds are then carefully inspected and all those which show no fuzz are picked out; for it has been discovered that naked seeds of Sakel do not produce lint of a good type. The selected seed, known as 'X' seed, is used for stock purposes; it is sown on some of the best fields on the estate. Part of the produce is again selected for growing stock seed marked as 'X' and treated in the same way. The balance is sown on some of the best farms and is known as 'S' seed. In the second year the 'S' seed is sown all over the estate, and provides a large supply of seed known as 'A' seed which is handed over to the Ministry for general distribution. In 1925 about 14,000 ardebs of 120 lb. of 'A' seed were provided in this way for the Ministry.

While work on a large scale has hitherto been confined to the Sakel seed, certain of the newer types are now being tested on the Domains with a view to distribution. In future the organization planned for supplying good seed to cultivators consists of (1) selection and isolation of small quantities from varieties raised at the technical laboratories' experimental grounds, Cairo; (2) the testing of these new varieties on the Ministry's large farms at Guimeza; and (3) the growing on of the best sorts on the farms of the State Domains Administration for general distribution.

The amount of pure seed produced on the State Domains is at present not enough for the requirements of the Ministry, and a considerable quantity of the seed distributed by it is purchased from ginneries. Purchases are made by a committee of the Ministry who take every precaution to secure purity. At the present time the Ministry is distributing from 17,000 to 18,000 tons of seed annually. of which about one-third has been grown under Government control either on the State Domains, or on the fields of selected cultivators ; the remaining two-thirds is purchased from ginneries.

The State Domains do not engage in cattle-breeding for sale, but breed and maintain a good quality of ordinary Egyptain cattle for their own purposes. They employ about 20 head of oxen per 100 feddans of cotton land. More animals are required during the cotton cultivation season than at other times of the year and in winter 14 head per 100 feddans of cotton land would suffice. There is now under consideration the possibility of reducing the cattle stock and substituting cultivation by tractors, but so far there has been little resort to mechanical cultivation.

The ordinary rotations adopted throughout the Egyptian Delta are : (1) a rotation covering 3 years commonly adopted on the State Domains, and (2) a 2-year rotation. The 3 years rotation represents a very intensive type of cultivation ; beginning about November 1st, the arrangement of the crops is as follows :—

1st Year—

Crop 1.—*Wheat* sown in October or November and harvested in the following May or June. The wheat stubble may not be watered until the flood season comes usually in the first week of August. Special permission may sometimes be got for earlier watering.

Crop 2.—After watering and ploughing, *maize* is sown which ripens in November.

2nd Year.—

Crop 3.—*Berseem* is sown as a catch crop in November and in January is ploughed in, in preparation for cotton.

Crop 4.—*Cotton* is sown in March and when the harvest is over, it is pulled out after watering the land in October or November.

3rd Year.—

Crop 5.—Just before the cotton is pulled out, or sometimes afterwards, *berseem* is sown broad-cast. Occasionally, the berseem may be sown earlier immediately after the first picking of cotton has been completed. When the cotton has been pulled, the berseem grows and is used as fodder until May or June.

Crop 6.—At this stage three things may happen : (*a*) if the land is rich, *maize* may be sown to be harvested in November ; (*b*) the land may be *fallowed* and wheat sown in the following autumn ; (*c*) if the land is salt, it requires *washing ;* that is, when the floods come in August

it is laid under water and remains flooded until October, when it is dried in prepartion for wheat sowing. The three-year rotation then begins again.

The two-year rotation is less complex ; it consists of berseem-cotton-wheat or barley-maize. About November 1st, when year starts, half the land will be under *berseem* to be followed in March by *cotton*. The remaining half will be under *wheat* or *barley* to be followed by *maize* on not more than a quarter of the whole area ; the rest is fallowed. Or sometimes *rice* is grown on the quarter section not occupied by maize, as a land reclamation crop.

In Egypt reclamation consists essentially of levelling and washing the land. Where salt is abundant, land must be washed at intervals of a few years. When this process is necessary, it is customary to grow rice, for it is found that rice is not much affected by salt, and the heavy soaking given to the rice crop washes the land. Rice straw does not seem to be used as a fodder ; the ordinary fodders are berseem, wheat and barley straw. The crop usually grown to provide concentrated food for livestocks is beans (Faba).

At Sakha, the central *teftish* of the Domains, all farmyard manure produced is used for cotton, but most cultivators apply this manure to maize. Maize is regarded as an exhausting crop, and at Sakha it is not favoured as a preparation for cotton, although many cultivators do grow cotton after maize. Artificial manures (almost exclusively nitrogenous) are used for wheat and barley. Wheat may get 50 to 100 kilos of nitrate of soda per feddan, barley 75 kilos. Artificial manures are little used for cotton in Lower Egypt, but in Upper Egypt nitrogenous dressings for cotton are common. Occasionally, the berseem crop gets an application of phosphates.

Good land on the State Domains would be expected to produce about the following quantities of crop per feddan : *wheat* 5 to 6 ardebs of 150 kilos, *barley* 8 ardebs of 120 kilos ; *maize* 12 ardebs of 120 kilos ; *rice* 8 to 15 ardebs of 120 kilos ; *cotton* 4 to 5 kantars (a grower thinks of a kantar as 315 lb. of seed cotton ; a merchant defines it as 100 lb. of lint.) ; *beans* 4 to 5 ardebs of 155 kilos. *Wheat straw* yields about 1½ tons, *barley straw* 1¼ tons, and *berseem hay* three quarters to 1 ton per feddan. Berseem makes about 2 tons of ensilage.

While the fertility of the soil of Egypt and the excellence of its crops must appeal to any visitor, the most noteworthy feature of its agriculture is the concentration of energy of all those responsible for the improvement of Egyptian agriculture on the cotton crop. The reason for this is obvious : while rural Egypt may be described as depending on the Nile, the wealth of urban Egypt, so obvious in Cairo and Alexandria, depends on cotton, and on the high rents which the recent prices of cotton have enabled Egyptian land to pay. Egyptian cotton is a very different product from that found in India ; the quality is exceedingly high and whereas in India there are many species contributing to the crop, in Egypt all the cultivated

varieties would appear to belong to one closely related type. It is indeed remarkable that in the case of a plant presenting so few morphological departures from a single type, results so striking have followed on the work of the plant breeder and selector. Egyptian experience is an indication of the scope of the field for effort that awaits those who attempt the improvement of Indian cottons. The existing types of cotton in cultivation in Egypt are all of comparatively recent origin ; and there is a considerable list of strains now competing for favour. At least eight types are being cultivated to some extent in the country, but for practical purposes there are only two or at most three cottons at present of importance, namely, Sakellarides grown in the Delta and Ashmouni (and the related Zagora) cottons of Upper Egypt. The former occupied 55 per cent. of the area under cotton in Egypt in 1926, and the two latter 37 per cent. A new variety of much promise called Maarad is now being introduced by the Royal Agricultural Society ; it comes from Pima cotton now grown in Arizona, but originally derived from Egypt. There is no indication that any cotton of foreign origin has been introduced and become popular in Egypt for over a century.

El Faiyum.

With the object of showing us an Egyptian Province which differs in many respects from the others, a whole day excursion to El Faiyum was arranged. Leaving Cairo by train, we travelled to Beni Souef, passing through a rich tract of Upper Egypt. In parts of this tract date palms were cultivated in quantity and the scenery recalled the Mahim District of Bombay. But for the most part the plain was treeless and covered with the usual maize, cotton and vegetable crops. It may be noted that the vegetables growing near Cairo, in early October, included chillies, brinjals, cabbages of various sorts, tomatoes and lettuce. Along the canal banks cultivators were everywhere watering their crops by means of the Archimedian screw, which is used when low lifts only are necessary. This screw is now being turned by bullocks or buffaloes pulling on a wheel to which the screw is geared.

Leaving Beni Souef, we crossed the narrow strip of desert country which separates the Nile valley from the Faiyum. The cultivated area of the Nile valley and of the Faiyum is here connected by a narrow cultivated strip alongside the canal. The Faiyum forms a shallow basin-shaped depression in the Lybian desert. In ancient times the flooded Nile used to escape into this basin, but the whole water supply is now controlled and depends on the above mentioned Ibrahimiya Canal. As compared with the Nile valley, the surface of the Faiyum is remarkably undulating. At points the elevation is 42 metres or more above sea level. (The level of the Nile valley at Beni Souef is from 27 to 28 metres.) In other places the levels in the Faiyum fall to a metre or less. Because of the rapid changes in level, water lifts are in frequent use, and heie we saw ancient specimens of the Persian wheel at work. We were told that they are not found in other parts of Egypt. As elsewhere a complete drainage system accompanied the irrigation channels, and the water which

flows in from the Nile ultimately flows off into a large lake, Lake Quarun, about 30 miles long and 5 miles broad, which occupies the north-west corner of the basin. The whole region is thickly populated ; the area of the Province is 413,000 feddans and the population 507,000. Because of the undulating surface, the land varied more in quality than is usual in Egypt, but on the whole it was thick and intensively cultivated. The sites of some of the villages were thickly planted with date palms ; there were enclosed gardens and fields and the general aspect was one of prosperity ; but we were informed that the cultivators of this region although skilful and industrious were poorer than in the Nile valley. The subsoil of the Faiyum consists of a porous limestone, which here and there had been eroded into narrow and picturesque gorges. Nowhere were these of great size, but in the usually flat Egyptian landscape these *wadys* were very picturesque.

Reclamation of land.

A visit to the Aboukir Land Company was interesting as showing us the methods adopted in Egyptian reclamation. These methods consist essentially of watering the land freely and providing a good system of drainage so that the salt is washed out of the surface soil. The process has long been known in Egypt and, under the guidance of engineers, land reclamation companies and others interested in land management, have reduced the washing and drainage processes to a fine art. The irrigation and drainage channels are laid out with great care so as both to economise labour in construction and to produce their effects thoroughly, and the amount of washing that is required to keep each section of the land free from salt has been determined with accuracy. The Aboukir Land Company was one of the pioneers of modern reclamation and at first had a very up-hill task, but now apparently the company is in flourishing circumstances. Its policy is to sell off land as soon as the soil has been thoroughly reclaimed, and of some 30,000 acres acquired by the company only 7,000 now remains in its possession. It is of interest to note that the first manager of this company was an Indian tea planter. The director's house is, in fact, a reproduction of an Indian bungalow and some of the methods adopted in engaging and managing labour followed Indian models. At one time the company were themselves responsible for pumping the drainage water from their estate, but recently a large pumping station has been erected by the Egyptian Government which drains the water from this estate and the surrounding districts. There are at this station six 130 H. P. Diesel engines and six centrifugal pumps, each of them lifting from 2·5 to 2·9 cubic metres per second through a height of 4 metres.

Cotton marketing.

When in Alexandria we called at the offices of Messrs. Caryer, who are large exporters of cotton. From them we ascertained that the destination of Egyptian

cotton has not changed much since before the War. There is a tendency for Continental Europe to take a somewhat higher percentage of the crop than previously, but it is not marked. Messrs. Carver buy much of their cotton direct from cultivators through salaried agents, but they also buy extensively from small dealers. There may be several of these smaller dealers intervening between Messrs. Carver's agents and the fellaheen. In view of the representations made to us as to cotton dealing in India, we questioned Messrs. Carver with the object of ascertaining whether complaints made by the fellaheen of the action of small dealers, weighmen and others who handle cotton were numerous. Apparently such complaints are less common than in India. Complaints had been made in the past, especially of fraudulent weighing, and as a result the Government have introduced what are known as cotton *halaqas* or markets at twenty-four important centres in Lower Egypt and twelve in Upper Egypt. The object of the *halaqa* is to protect the fellah from fraud; they are enclosed markets conveniently situated on the principal agricultural roads and are under official control. In charge of each of the larger *halaqas* there is an official weigher and a gate-keeper. In the smaller markets the official weigher is in sole charge. Each morning a telegram received from Alexandria, giving the opening price of cotton there, is posted in the market, and should any important change in price take place during the day, a second telegram is posted. Cotton merchants can hire offices or stands in the *halaqas*, as can also the *qabbani*, the equivalent of the Indian *adatiya*. Any *qabbani* convicted of fraudulent weighing or dealing has his license cancelled.

Stringent laws exist against mixing of strains before cotton is ginned. The damping of cotton is regularly practised. In the Sudan cotton must be damped before ginning, and in Lower Egypt it may also be necessary in hot dry weather to damp the cotton slightly before it is pressed. We saw the damping process in progress at one ginnery; the bales were sprinkled from an ordinary garden syringe, the amount of water added would have a negligible effect on the weight, and we came to the conclusion that the object of damping in Egypt was not to secure the benefit of the extra weight of water, but to bring the fibre into a condition in which it could safely be heavily pressed.

Although Alexandrian merchants maintain that no serious amount of watering goes on in Egypt, the watering of Egyptian cotton is a frequent source of complaint by buyers on behalf of European spinners. In their view cotton should not contain more than 8½ per cent. of moisture, whereas occasionally as much as 12 to 14 per cent. has been detected in bales. Messrs. Carver's opinion is that cotton requires from about 8½ to 9½ per cent. of moisture for pressing, and apparently this represents the general views of Alexandrian merchants. The merchants' associations ask dissatisfied spinners to furnish them with specific cases of over-watering, and state that if these were brought to their notice, everything possible would be done to check excessive watering on the part of exporters. With reference to the heating of cotton seed to kill pink bollworm, we were informed in Alexandria that it cost

more to treat the seed than it did to gin the cotton. This statement was not substantiated by a cotton ginner in the Delta ; the opinion was expressed that the cost of ginning was not a heavy charge and that in fact no large ginning factory need have any difficulty in complying with the Government's requirements. We were unable to get any figures showing the cost of this method of treating seed. The subject may become of importance in India in view of the ravages of the pink boll weevil in the United Provinces and the Punjab. Experiments in heating the seed are now in progress both at Cawnpore and at Lyallpur.

THE CANE POSITION IN NORTH BIHAR WITH SPECIAL RELATION TO THE FACTORY INDUSTRY AND THE EARLY CRUSHING PROBLEM.

BY

WYNNE SAYER, B.A.,

Secretary, Sugar Bureau.

It is now some 6 years since the original Co. canes—Co. 214, Co. 210 and Co. 213—were selected, tested and distributed to growers in North Bihar by the Sugar Bureau and in the interim with the exception of the distribution of Co. 205 as a cane for special conditions, these canes have been allowed to find their own level among growers and it has been possible by carefully noting the results over a number of years to check out and correlate the exact type of cane which is required in the tract.

The position in North Bihar is probably unique in cane growing countries. Such are the climatic and rainfall conditions that it is possible to have a couple of years in which it would be perfectly feasible to grow tropical canes and grow them satisfactorily. But such a couple of seasons might be followed by a year in which Co. 205, which is the hardiest of canes, would alone do really well and all the tropical canes would fail entirely, while after this might come a less noticeable variation over a period of years in which Co. 210 and Co. 213 would alternately prove the better suited to the prevailing conditions. Such climatic variations make the selection of a standard cane a matter of very great difficulty, and as in the present state of the industry it is essential to secure a large and regular cane tonnage for both mills and growers, the writer considers that the time has come to review carefully the present position and see in what directions we can safely advance and where, in the light of the experience we have gathered, it will be necessary to retreat slightly in order to consolidate the position. At present we have a rainfall of 45 inches spread over 4 months during which it is by no means regularly distributed. It may come late and cease early. It may come early and cease late or come early and cease early, all the variations in the rainfall affecting the growth and ripening of the cane in proportion. We are therefore forced in selecting a cane to take into consideration all these extremes in rainfall coupled with the fact that the cane must be able to keep itself alive, if necessary, through the three hottest months of the year, which can pass without any rainfall, and then immediately the rains break, come away and grow at a record speed to ripen in November with a decent tonnage. It will thus be seen that a standard cane is almost impossible and it is necessary to have a selection of canes to suit the variation of the seasons and, in

short, the grower must never pin his faith to one type of cane alone. Four types of cane are now being grown.

Co. 214, an early ripener with high sucrose and low tonnage, very hardy, essentially a mill cane and as such not in favour with free growers.

Co. 210, a medium cane for light lands, a good cane in a short rainfall and an excellent ratooner.

Co. 213, a medium thick cane for good lands with high tonnage in a good rainfall year but unable to give full tonnage unless the rainfall is right up to average.

Co. 205, a hardy cane for bad lands and water-logged areas; essentially a cane for areas where no other cane will grow.

It will thus be seen that most of the climatic variations have been guarded against in giving out these canes and the grower who cultivates all four is almost certain of a good crop from two of them whatever the year may be. Now it must be realized that so long as mills and growers are independent of each other, there can be no settled cane policy. The mill wants sugar, the grower wants tonnage and these two points are at present not easily combined in the same cane under North Bihar conditions, especially in the direction of early crushing. To obtain the extra sugar the mill offers a premium to make up for the smaller tonnage produced per acre by the grower if he plants the present type of early ripening cane. *Now* early ripening canes, if the mill *can* and *will* take them off in early November, undoubtedly offer a great advantage to the grower, who can get his land cleared and resown for *rabi* and this to some extent does compensate for tonnage losses, but on the other hand the position of the grower who has relied on this fact and yet finds the mill delaying its opening is parlous.

But the mill has also perfectly definite reasons for such delay. No mill is going to start in early November to crush a few thousand maunds of Co. 214 or a similar early ripening cane and then be forced either to close down or continue its run on unripe cane of another variety until the later ripening canes are ready owing to a lack of supplies of early cane. This means a dead loss to the mill. It is thus clear that under present conditions early starting and the growing of early ripening canes are linked together, and that unless the growers each do their share towards putting down or guaranteeing a small area of early cane, no mill can or will open early. Unless we have early opening, *no advantage from the grower's point of view is to be found in growing Co. 214 or any similar low tonnage early cane.* Should the mill possess sufficient land of its own to enable it to grow early cane for November crushing, well and good—failing that, it is forced back on to premiums and other unsatisfactory methods of ensuring a supply.

This question of supply is a vital one. The longer season a mill can work, the lower the overhead charges will be, but the length of the actual working season is considerably affected by two factors :—

1. The percentage of sugar in the cane.
2. The percentage of sugar the mill obtains.

That is to say, no mill can work at a profit on normal sugar prices if it is not extracting a certain percentage of sugar from the cane and the most efficient mill in the world cannot extract sugar which is not present in the cane. Therefore no mill is going to start working unless it has a certain percentage of sugar available in the cane which it can reasonably expect to extract or is forced to get off a big crop under agreement between dates.

Now assuming that October to June is the longest possible crushing season. limited at the end by lack of cane and at the beginining held back by absence of sugar, at present with a big crop half November-December-January-February-March-April are the milling months covered by the canes Co. 210 and Co. 213 and Co. 205 which are the standard mill canes through these months. May and June only come in if there is an excess of cane and this working is a source of considerable profit to the mill but is not regarded favourably by the grower who sees his cane drying on the field and has endless trouble in getting it cut and stripped as the tops have often dried off. We have then October and half November to deal with and these 6 weeks represent the early crushing season, a period when the grower is anxious to supply all the cane possible in order to clear his land and sell his cane at its greenest, while the mill hangs back in the case of ordinary canes—waiting for the sucrose content and the purity to rise and finally starting on ratoons if no early ripening cane is to be had. At present Co. 214 represents the only cane which can really be worked at a profit during this period (I am taking an average year and not dealing with short rainfall or a protracted monsoon, both of which occurrences affect cane ripening and expedite or delay the mill opening) but does not represent a cane which is ever likely to be popular with free growers who are paid on a tonnage basis.

Now there are two ways of obtaining a certain amount of sugar per acre, which is the factor the mill looks at and on which payment for cane is based.

1. By growing a high sucrose cane of comparatively low tonnage.
2. By growing a lower sucrose cane of higher tonnage.

The amount of sugar obtained by the mill is the same, but in the first case it pays less per acre for its raw material and has to crush less. In the second case, it pays more per acre and works more cane.

To-date we have tried 1 and it has proved a failure and has only been kept alive by the payment of a premium. Now it is obvious that, if we can strike a mean between 1 and 2, we have every chance of reconciling mill and grower by giving the grower a chance to make as much money per acre on a tonnage basis as he can with the later ripening canes, while the mill gets its sugar and its extended working season and pays no actual premium.

To accomplish such a reconciliation, we must have a high tonnage, good sucrose, early ripening cane, and if we can get these three factors combined, other minor points will have to be passed over. The independent grower is a free agent and

the mill is dependent on the grower and therefore both sides must try and meet each other in this matter.

Payment by sucrose basis is often advocated as a method for getting early ripening canes grown. In India, where the majority of small growers are illiterate, it is merely a further opportunity for the weighing staff to swindle the grower and, pending the arrival of the millennium described as compulsory universal education, no steps can be taken to introduce such a system—whatever may be the practice in other countries. The position may therefore be summed up as follows :—

To ensure early opening and a full supply of cane, it is necessary to give the grower a tonnage cane; which the mills demand must be fully forward, say 80 purity by mid. October. Such a cane is yet to find and my last examination of the new canes in the testing plots at Pusa leads me to believe that certain changes will be required, as the essentials required are not to be found in combination in any known cane yet, but this is dealt with further on. Leaving aside the question of special canes, early and late, for special types of land and conditions, which are an outside line of work, we will now come to the main crop.

Here we have two points to consider :—

(A) The big tonnage cane which requires a full monsoon to show its best—but loses heavily if conditions are unfavourable.

(B) The medium tonnage cane which can improve in tonnage with favourable conditions and does not drop so heavily if rainfall and conditions are unfavourable.

A and B above represent Co. 213 and Co. 210 and from the details I have collected in the past few years it is clear that conditions and opinions are changing. When the three canes Co. 210, 213 and 214 were first given out in 1923, everyone took up Co. 213 and with the exception of a few places (mostly large growers' estates on light land) Co. 210 was not regarded favourably. while Co. 214 was looked upon as a clear example of favouritism towards the mill. The ryot went entirely for Co. 213 regardless of what class of land he was going to plant as it was the heaviest yielder.

A survey of the position now shows that Co. 210 is steadily and surely consolidating its position and is gradually working its way into the place formerly occupied on certain classes of land by Co. 213. It is the reason for this change which is the important thing to discover, because it must obviously influence future cane policy in the tract as Co. 210 and Co. 213 are not by any means canes for similar conditions.

With the grower paid on a tonnage basis it is evident that tonnage is the acid test on which the change has come about.

Examination of Co. 213, however, does not show—

(1) That it suffers more from disease or from borer.

As regards borer attack, no Co. cane in particular can be said to suffer badly, though Co. 210 with its up-right flag shows borer attack more distinctly

than the other canes, but the great vitality and growing power of these canes enables them to grow past top borer attack to a great extent and Co. 213 cannot be said to be inferior to Co. 210 in this respect.

In the case of mosaic disease, though Co. 213 has slightly more mosaic infection than Co. 210 (0·3 and 0·05 per cent. respectively) as found by taking 7 samples from 7 separate estates, evenly distributed through the cane growing area of North Bihar, yet the total amounts are so small that no drop in tonnage could be traced to such infection and no differentiation between the canes on this account could be sustained.

(2) Any sign of tonnage drop under favourable conditions.

As regards tonnage, Co. 213 is still an easy 200 mds. ahead of Co. 210 in a good year and as a strong land cane in a good rainfall year, it has capacities for tonnage which Co. 210 can never attain to.

(3) That it is any harder to handle or more troublesome to grow than Co. 210.

The exhaustive and thorough tests these canes were put through before distribution included all these points and the conclusions arrived at then still hold good everywhere.

The reason is a deeper one. Since the distribution of these canes in 1923, the monsoon has shown a distinct tendency to lighten. The actual total rainfall for the year may appear the same or even show a slight increase, but an increasing quantity of this rainfall is received in fractions of an inch and not in the steady heavy falls required to grow a big cane. It will thus be seen that it appears as if the actual effect of the rainfall was on the light side as compared with past years. Now such a happening at once limits the land on which Co. 213 can do really well and increases the area on which Co. 210 may be expected to do its best and the result is as above. The lighter and more resistant cane is proving the most reliable cane over the average of years and it would appear that this fact must be carefully borne in mind in selecting suitable canes for the tract in the future.

Such a statement in no way governs areas where the rainfall is heavier or where facilities exist for helping the cane along. Such places should always be able to maintain a class of cane in keeping with their conditions. The question to be considered is whether they are at present growing a good enough class of cane. Similarly, the position in those estates where irrigation is possible requires further consideration. To irrigate a cane which can hold its own without irrigation invariably increases the yield—but it is an open question as to whether you are getting as full a return for your money as if you were dealing with a cane which had a higher sucrose and a lower drought resistant ratio—because it has already been clearly shown that the optimum cane requires optimum treatment, and resistance and hardiness are not factors which march hand in hand with high sucrose and a low fibre ratio—the two essentials of a big sugar producer.

The final review therefore shows us that we still lack the essential high tonnage, early ripening cane for October-November crushing and that such a cane is not yet in sight, while Co. 214, the present cane, is unable to hold its ground with free growers unless it receives a premium and is grown in sufficient quantity to give the mill a clear run.

Co. 213 and Co. 210 have both succeeded, but the tendency is to ensure a crop by growing Co. 210 on any lands which are affected by short rainfall and thus Co. 210 is gaining ground from Co. 213 which still, however, remains the stock cane. Co. 205 grows on and has proved an excellent cane for the special conditions it was given out for. The mills are therefore assured of a big crop in mid. November-December and it is the 6 weeks early crushing which is still to be provided for.

So much for the agricultural side of the shield. Let us now see what has been done on the manufacturing side and how this can assist us in the solution of the agricultural problem.

When the Sugar Committee toured India in 1920, the average mill efficiency was about 6 per cent. sugar on cane. It is now in the region of 8·5 per cent. Now excluding canes like Uba which are a trouble from the crusher *to the crystallizer*—the average cane parts with its juice at the mill and from there may be considered similar to all other equally ripe canes in the hands of expert sugar boilers handling proper sugar house equipment. All the actual mill is concerned with is the smashing up of the fibre of the cane and the extraction of the maximum juice. Modern improvements have now produced milling outfits which are simply wasting money in crushing canes like Hemja. This sounds a revolutionary statement, but a close examination of conditions will show what is meant. It is essential for a mill to obtain the maximum amount of cane tonnage it can work to enable it to keep down its overhead and increase its efficiency (*in the past short cane supply and irregular working was responsible for bad figures just as much as bad work*), and the low tonnage of Hemja and similar canes is liable to keep such a plant working short time and thereby increasing overhead charges and preventing the earning of a decent profit. It is no exaggeration to say that at least one mill in North Bihar, crushing a big crop this year, would have been obliged to close down if it had crushed nothing but Hemja. *It could not have obtained the necessary tonnage on the area from which it drew its supplies to enable it to work at a profit.* On the other hand, if a plant has increased its milling efficiency to such a degree that it is able to deal equally effectively with higher fibre canes it at once will find itself supplied with a big crop of cane willingly grown by free growers with a far greater seasonal range than that provided by local low fibre canes. The immediate success of Co. 210 and Co. 213 is the proof of this. Now good sucrose content, low fibre and heavy tonnage are a trio which are found in a good many thick canes but it is a curious but none the less existing fact that the higher the sucrose content in non-tropical canes, the worse the agricultural performance seems to become, and the higher the fibre content as a rule, the stronger grower the cane becomes—*but it does not*

follow that the higher the fibre content becomes, the lower the sucrose—the sucrose merely becomes harder to extract.

When we take into consideration these factors, we at once see that if hardiness and good agricultural habit are linked to high fibre content, it is obvious that any really early ripening cane of this class will of necessity have to be a hardy cane of high tonnage with only one point against it—high fibre. Without this it cannot grow the tonnage under unirrigated conditions. This cane, it must be remembered, has got to grow tonnage and ripen off to a high purity in five months or less, besides keeping itself alive on the residual moisture for the preceding 3 months—a period during which hardly any noticeable top growth can be made. Such demands on an early ripening cane are made by no other cane country in the world and this is why the production of such a cane involves such difficulty. It must have exceptional vigour or it cannot produce the tonnage in the time, and without a high fibre content I do not think we can get the necessary vigour allied with the early ripening. Now we have already shown that without tonnage we cannot hope to get any early cane grown and it has already been demonstrated that in the case of the present fibre ratio of Co. 213, really early ripening and heavy tonnage will not correlate. It would therefore appear to be the best solution to equip the mills to deal even more effectively with fibre and then proceed along this path towards an early ripening heavy tonnage cane.

In the past we were limited by milling efficiency. Co. 214, which is now dealt with by the mills without trouble, required considerable attention when first put through, but there is no doubt that the 14 and 17 roller plants now working, if equipped with shredders or knives, can deal even more efficiently with a large tonnage of high fibre canes. *An expenditure of a given sum on knives or shredders would bring in an immediate return, while the same sum would not guarantee a low fibre high tonnage early ripening cane.* Our general conditions appear to demand a higher factor of security on the agricultural side than was accepted in 1922, and I consider that the improvement in the milling has given us a larger margin for securing this factor than any agricultural improvement can in an unirrigated tract.

Now Co. 214 at present receives a premium of one anna three pies per maund to compensate for a tonnage drop on Co. 210 and Co. 213. It also can, if all the other factors are favourable, expect to be off the land by the end of November at latest and these are the points in favour of the grower.

Now the mill can get 9·25 per cent. out of this cane with early crushing in a sulphitation plant or 9·5 per cent. if worked by a carbonatation factory. This is excellent work for the commencement of a season showing almost the season average at the start. The sucrose of Co. 214 is undoubtedly high, and such high sucrose is, as is generally recognized, not a factor which goes hand in hand with good agricultural habit.

It therefore becomes obvious that if we turned to a cane with lower sucrose and early ripening, out of which the mill could start with say 8 per cent., we might

reasonably hope to get a higher tonnage cane, as we should be working with a group of seedlings whose lower sucrose content might reasonably be hoped to be linked with a better agricultural performance, the early ripening factor being maintained. A 17 roller train with knives would deal effectively with such a cane, given that its fibre was not over 20, while a mill with a shorter train and knives could at least expect an improved result.

Under such circumstances we should then find ourselves in a position far more satisfactory for all parties, *i.e.*, with an early ripening cane with which growers were satisfied on a tonnage basis and for which mills would pay the basic rate, early clearing still standing as an additional advantage to the grower, while the mill could reasonably expect to obtain 8 per cent. at a start in a well equipped and intelligently operated factory.

It is therefore a matter for earnest consideration how far the mills are able and willing to assist growers in their areas to grow an improved tonnage, early ripening cane. At present, the attempt to link up on these lines has practically failed and as a result the mills are likely to lose a good mill cane through the inability of growers to face the drop in tonnage so far inevitably linked with a very early ripening cane. The remedy is to remove this tonnage drop—while preserving the other factors—and it appears to me that in this work the mills can assist materially and to a great extent simplify the breeding problem by enabling the range of canes to be enlarged.

The power of the mills to get the best out of any cane has vastly increased since first North Bihar started cane on a large scale. The cane side of the industry has also made a big advance and the combination of the two has produced a successful sugar industry. We are now faced with a problem where both sides must unite to solve the difficulty. The grower must realize that to some degree he has got to meet the mills over this combination of premium and tonnage and that it is useless asking for the impossible because closure of the mills will be equally harmful to him as an agriculturist, while the mills must do their utmost to increase their efficiency to enable them to deal effectively with the class of cane which climatic conditions force upon the growers. It is no use either side looking to other countries for help. The conditions which have produced this problem are peculiar to India and its solution has to be worked out here. The result will be to the benefit of all concerned and will be another step on the ladder towards making North Bihar a real sugar tract.

TUBE WELLS AND AGRICULTURE.

BY

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(Concluded from Vol. XXIII, Pt. 5.)

THE open circular well lined with brick or stone is familiar to everyone. Fig. 1 shows the type in common use all over India. Such wells vary from 10 to 15 feet in diameter ; the foot or base is carried down until a stratum of water yielding sand is encountered. Sound judgment and knowledge of the locality are necessary before an attempt to find water is made ; should a suitable sand stratum not be struck within a depth of 20 feet below spring level, the expense of further sinking becomes prohibitive.

Open wells for irrigation exist in thousands ; some of them are very old and deep, as much as 60 feet from ground to water level. Wherever open wells are in service, there tube wells also will prove a success. We may make use of the knowledge acquired by trial and error years ago to guide us at the present day.

There is, however one fundamental difference between the open well and the tube well : the open well admits water only through the porous sand exposed at its base ; the tube well, on the contrary, has its base blanked off and water is taken in through its cylindrical outer surface (compare Fig. 1 and Fig. 3).

The effect of this difference of principle is profound. An open well having a base area of 80 square feet yields about $\frac{1}{10}$ cusec (37 gallons per minute), while a tube well with a cylindrical outer surface of the same area will yield $\frac{1}{2}$ cusec, an amount 5 times as great.

The inferiority of the open well in respect to water yield per square foot of percolation surface is partly explained by the fact that it is not possible to take water rapidly from an exposed surface of sand, due to the liability of sand to lift and pass away with the water, but this action cannot account for more than $\frac{2}{5}$ of the difference stated. The real cause for the relatively small quantity yielded by open wells is to be found in the direction of approach of the water, vertically through the sand in the case of the open well, and horizontally for the tube well.

Sedimentary deposits of sand and clay are always stratified horizontally. Even a thin stratum of clay presents a formidable obstacle to the vertical passage of water, but none to horizontal flow. There is also good reason for believing that the subsoil sands offer less resistance to horizontal than to vertical travel.

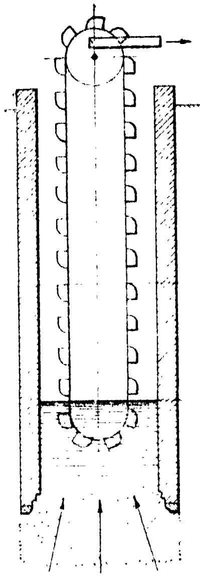


FIG. 1

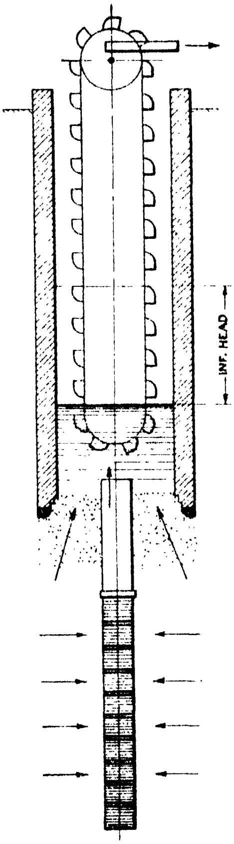


FIG. 2

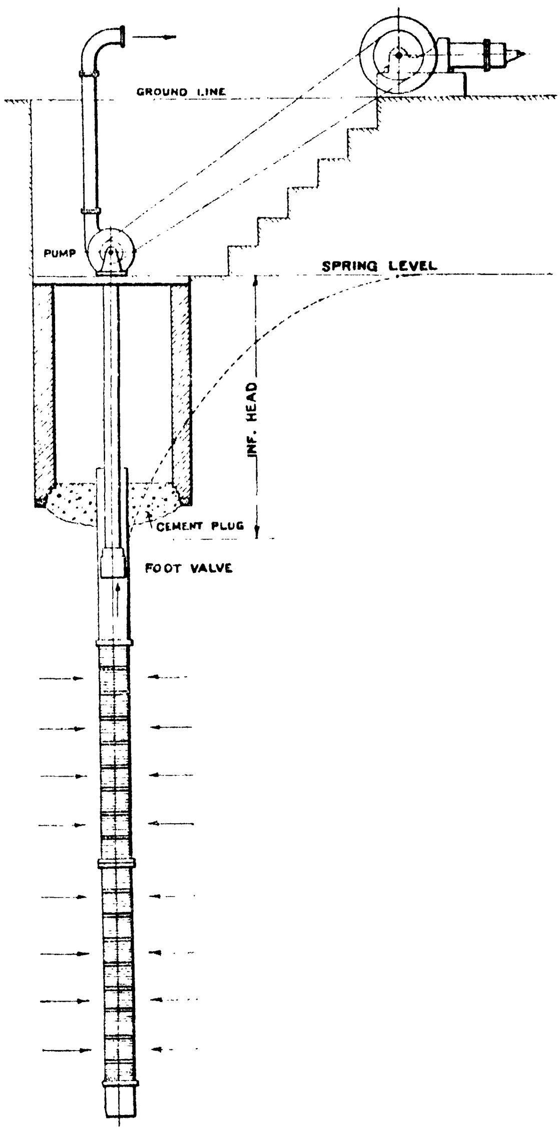


FIG. 3

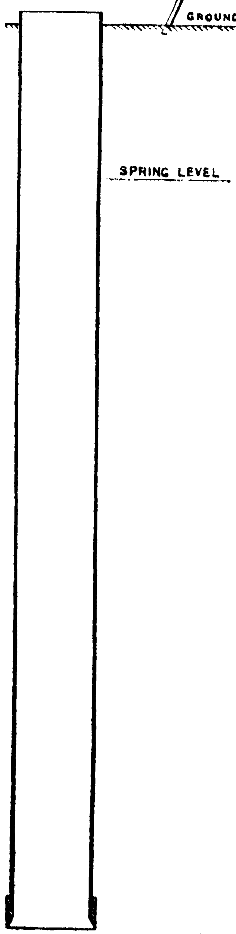


FIG. 4

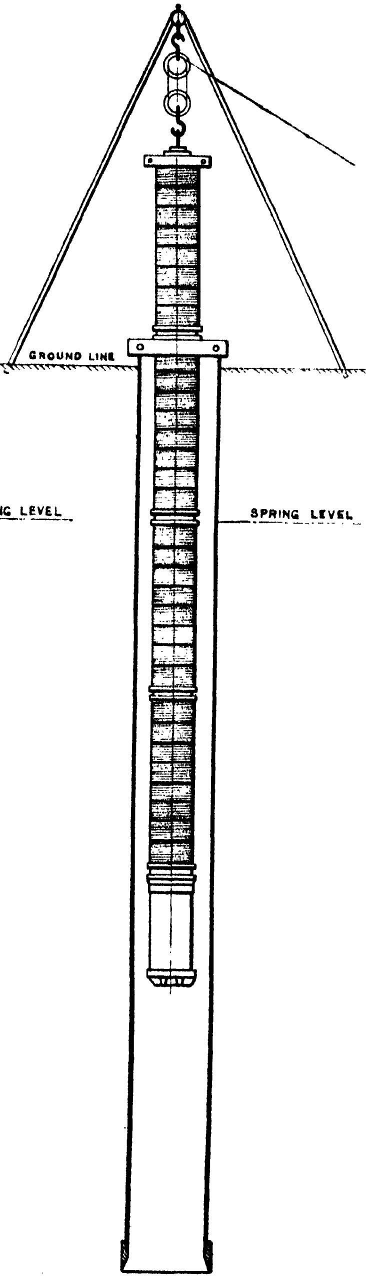


FIG. 5

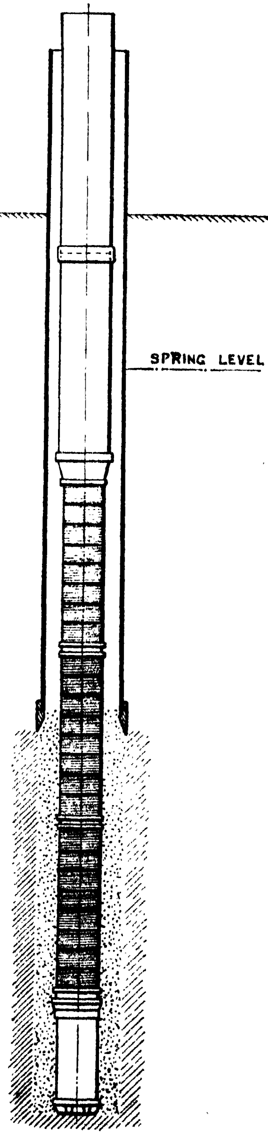


FIG. 6

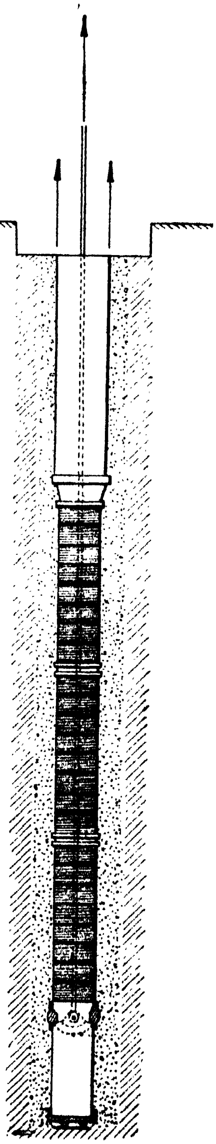


FIG. 7

The yield of water from any sort of well cannot be predicted with certainty, although we have a general knowlegde of the geology of the district where it is proposed to sink wells. There are always some blind spots shielded by ancient clay beds wherein very little water is found ; consequently, well sinking is speculative. The tube well is better in this respect than the open well by reason of its greater depth and the chance of piercing good sand strata below the level at which the base of the open well must be situated. No data is obtainable concerning the proportion of failures with open wells, but it is estimated that 1 in 10 fail to tap the right stratum, resulting in financial loss and disappointment.

The risk with tube wells is considerably less. The sinking process permits exploration of the sub-soil to depths of 300 feet below water, or more. The site selected must be very bad to fail entirely in these circumstances.

At the same time, experience has shown that promising sites have not given the supply anticipated, while other sites have greatly exceeded expectations. Tube well engineering has, however, now reached a stage when it is possible to forecast with reasonable accuracy the yield from various classes of sand after a boring has been made, but not before.

The three operations comprising the installation of a tube well are, firstly, the sinking of a plain tube, Fig. 4, to a depth determined by the quality and thickness of the water bearing sands passed through ; secondly, the lowering of the tube well inside the sinking tube, Fig. 5 ; thirdly, the extraction of the sinking tube leaving the tube well in contact with the sub-soil, Fig. 6, and the completed well is shown by Fig. 7.

During the first operation, Fig. 4, samples of the sub-soil are taken from the material brought up by the excavating tool and tested for porosity. The writer employs the Kennedy method of wet testing, which indicates the proportions of coarse sand, fine sand, clay, or other constituents of the strata under examination, and a fairly accurate estimate of the yield is thus rendered possible.

Should the tests not disclose a sufficiency of porous sand, the sinking tube must go deeper in the hope that a satisfactory stratum will be met, failing which the sinking tube should be withdrawn and re-sunk elsewhere. It will be observed that the only financial loss is the expense for sinking and withdrawing the first tube, the tube well proper not having been lowered into the ground.

Turning now to the majority of tube wells, those sunk in good sand, the yield per square foot of strainer surface averages $1\frac{1}{2}$ to 2 gallons per minute. A large well producing 2 cusecs requires 150 feet of 12 inch strainer. The present day tendency is to use large strainer tubes, up to 20 inches diameter ; the larger the strainer the less the depth of the well.

Any well, tube or open, has an ouptput strictly regulated by the infiltration head, or draw down, to which it is subjected. The output of an open well is again limited by the exposed sand at its base. An infiltration head exceeding 7 feet cannot be applied to open wells.

By the term, infiltration head, is meant the difference of water level inside and outside the well when water is being withdrawn from it. The output is exactly proportionate to the infiltration head ; a well yields twice as much water with 6 feet of draw down than with 3 feet.

There is no limit to the infiltration head which may be applied to tube wells from engineering considerations, but there is an economic limit. A high infiltration head means that water has to be lifted through a greater vertical distance ; more power is consumed in the performance of this extra work. 14 to 20 feet is the usual head allowed for irrigation wells. It is cheaper in the long run to provide ample capacity in the well than to face a continued expense for fuel or electricity.

To proceed now to the engineering methods in vogue, the simplest form of tube well is that illustrated by Fig. 2. The tube is sunk below the base of an existing open well. No alteration to the appliances for lifting the water from the open well is necessary.

Supposing that $\frac{1}{16}$ cusec (37 gallons per minute) was the yield of the open well before sinking the tube, the provision of one 8 feet length of 8 inch diameter tube will double the yield, without affecting the previous infiltration head.

The cost of such a tube well, including sinking and installation charges, will be about Rs. 750, a moderate expense for twice the water.

Another type of installation belonging to the improvised class, largely used because of its appearance of simplicity, but defective in principle, is shown by Fig. 3.

Here we have an open pit, lined with brickwork ; the bottom of the pit is situated as low as excavation under water will allow, and plugged with concrete to exclude the sub-soil water as much as can be done with the inferior building materials at hand.

A centrifugal pump, belt driven from an oil engine or electric motor standing at ground level, is connected direct to the tube well ; no water enters normally through the plugging.

To secure a reasonably large output from a tube well, the infiltration head must not be less than 14 feet. The problem is how to obtain it with this class of installation and herein lies the defect referred to. The open pit cannot be made perfectly watertight ; when the pump is idle, water will rise in the pit and remain there at spring level.

Spring level is not constant, seasonal variations are of the order of 6 feet, and heavy local rains may cause an even greater rise. The pump must therefore be located above the highest spring level likely to occur, which means that in ordinary practice a suction lift exceeding 20′ is common. No centrifugal pump will operate efficiently on so great a lift with tube well water, which is charged with gases.

This scheme is moreover defective in another way. The greatest suction lift takes place in the dry season. The tube well discharge is consequently at a minimum when water is most wanted. Nevertheless, where engineering skill is but moderate, this system will continue to be used, in spite of its defective principle.

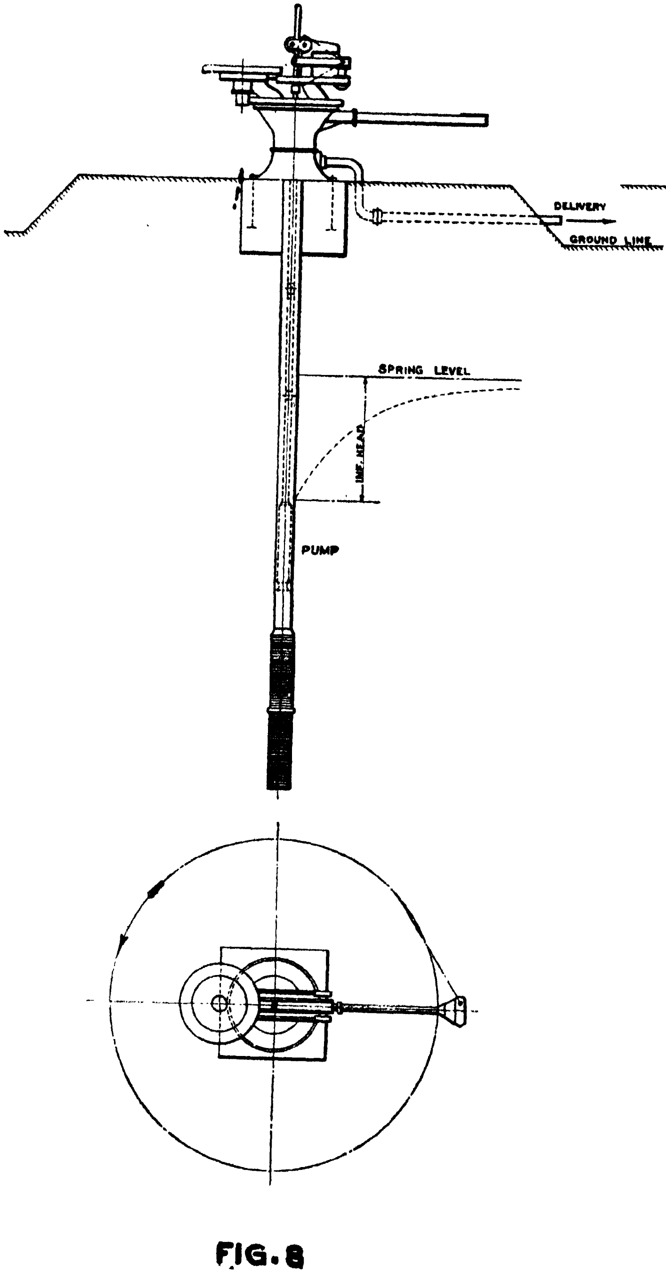

DELIVERY
GROUND LINE
SPRING LEVEL
INF. HEAD
PUMP

FIG. 8

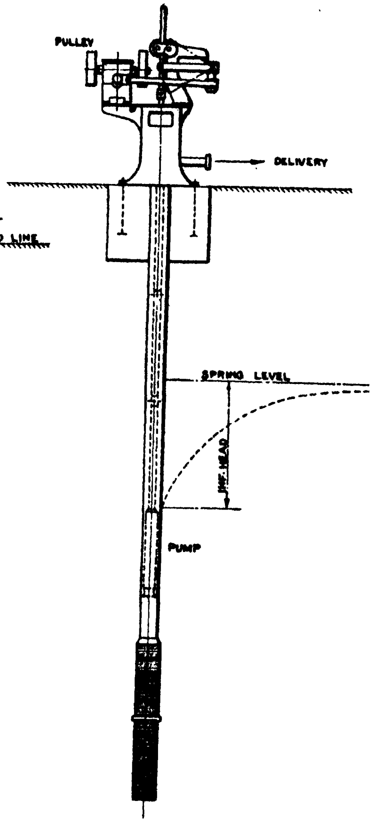

PULLEY
DELIVERY
SPRING LEVEL
INF. HEAD
PUMP

FIG. 9

Before leaving the class of installation requiring an open well or pit to contain the pump or water lifter, mention should be made of the Boulton elevator, a neat and compact device, in appearance not unlike a Persian wheel on a smaller scale, but differing therefrom in its constructional details. The Boulton elevator will go down an open well as small as 6 feet diameter ; it may be driven by animal power or engine power for raising small supplies up to $\frac{1}{4}$ cusec, and it should have a wide application.

Pumping by compressed air may be ruled out as totally unsuited to irrigation ; the power consumed by air lift is from two to three times that taken by pumps. The examples at the end of this article will make clear that the cost of power is of primary importance ; only the most efficient means of lifting water need be considered.

Attention will now be directed to the more recent developments of tube well engineering, with which the writer has been closely associated as inventor, designer, and manufacturer. The Central Workshops at Amritsar stand alone in the East as the sole manufactory where all that is necessary to first class engineering of this kind can be actually produced without recourse to importation, in direct competition with America for the tube well proper, and with Europe for borehole pumps.

The first modern installation outside America, comprising an all-metal tube well containing a submerged borehole pump electrically driven, was constructed at Amritsar about 12 years ago. Since then numerous wells, some of the largest size and depth, have been made for most provinces of India. What follows may therefore be taken to represent the current practice of the writer, making use of his own records and designs.

Since the yield from a tube well cannot, with our present knowledge of the subject, be predicted with certainty, it is evident that the dimensions of the well, pump, and source of power must be estimated in advance ; not until a test has actually been made, can this estimate be verified.

The yield of a well being proportionate to the infiltration head, should the yield by actual test prove less than estimated, the natural course will be to increase the infiltration head and so obtain the quantity desired.

To carry this plan into effect, it will be clear from previous explanations that a submerged pump is essential in order that a high suction lift may not defeat the object in view. A submerged pump situated in the tube itself below lowest recorded spring level is consequently incorporated in modern designs.

Commencing with the smaller sizes, Fig. 8 represents a tube well fitted with a submerged reciprocating pump, suitable for raising $\frac{1}{8}$ cusec (47 gallons per minute) through a total lift of 50 feet, or alternatively, 35 gallons per minute through a lift of 75 feet.

The pump head is designed for animal power. Two bullocks or two camels can raise the quantities mentioned continuously without undue effort. The circular

path and draught pole with seat familiar to users of the ancient Persian wheel have been retained, and animals are easily trained to preform this simple duty.

The machinery is self-lubricating and dust proof for operation in the open air without a covering. The pump may be withdrawn through the centre of the pump head for examination without disturbance to the heavier portions, and no troublesome excavations below water level are necessary as all working parts are situated above ground and readily accessible.

The pump is double acting, operated by a single rod, compensated hydraulically to even out the strain on the animals, and compensated separately in a novel manner to suppress entirely the shocks inherent in ordinary reciprocating pumps, which have hitherto prevented their use in tube wells.

It will be noticed that the working parts are collected at the centre of the circular path, the animals are not compelled to step over a trough containing a revolving shaft at frequent intervals, as usual with other water lifters. Anyone who has watched the distress caused by constant misses of foothold will agree that gaps in the track should be avoided.

This combination of tube well and submerged pump should find service whereever the spring water level is too low for the Persian wheel, say over 25 or 30 feet. Continuous steady movement of animals enables more water to be raised with less fatigue than is the case with intermittent action on inclined planes as seen in the central parts of India. In general, whenever an animal is obliged to walk away with its load and return unloaded to the starting point to complete the cycle, the amount of useful work done by the animal is about half what it would have been had continuous forward movement been possible.

It will be understood that the power developed by two bullocks is equivalent to one horsepower ; the output of a well to which animal power is applied is in consequence limited to $\frac{1}{8}$ cusec, lift 50 feet.

The cost of a tube well fitted with the submerged reciprocating pump described, including two 5 feet lengths of 8″ strainer tube, is about Rs. 2,100, a figure which a large scale manufacture will in time reduce.

Another type of small tube well and submerged pump, similar in many respects to that just described, is illustrated by Fig. 9. This example is power driven by belt to the pulley seen on the left of the pump head ; the source of power may be an oil engine or electric motor. An alternative method of driving, not illustrated, is a direct coupled electric motor to occupy the place of the belt pulley. Either continuous or alternating current may be used. The speed of the pump is constant for all lifts.

Much care and thought has been devoted to the lubrication of the head gears of these small pumps. Working parts are enclosed and automatically lubricated ; no attendant is necessary for the power driven type, and a daily visit will suffice.

With power drive, no limit to the quantity of water lifted is imposed, except that brought about by the capacity of the pump. The smaller of the two sizes or-

responds to the duty of the animal power pump, $\frac{1}{8}$ cusec (47 gallons per minute) through 50 feet, and 35 gallons through 75 feet; intermediate quantities and lifts are catered for by variation in the stroke of the pump, an adjustment provided also for the animal power variety.

The larger size is designed for $\frac{1}{4}$ cusec through 50 feet, double the capacity of the other, and the same constructional plan is followed throughout.

Economy in power consumption has been carefully studied. None but the most efficient pumps or water lifters find a permanent place in irrigation practice. Long working hours are the rule. The industry cannot afford to pay big bills for oil or electric power, power being the principal item of expense.

The efficiency of pumping, all losses included, from the water in the well to the exit of the discharge pipe, is 70 per cent. with these reciprocating pumps; thus $\frac{1}{8}$ cusec lifted 50 feet demands one horsepower, and $\frac{1}{4}$ cusec two horsepower. One gallon of the cheapest kerosine will run the $\frac{1}{8}$ cusec pump for 12 hours. Should the lift be less than 50 feet, the fuel consumption will be less in almost exact proportion.

Although not related to agriculture and irrigation, it may here be pointed out that small wells and pumps of this class are eminently suitable for village domestic water supply; dirt or foul surface drainage cannot enter the tube, a thoroughly clean and sanitary drinking water service is assured by the all metal construction, the tube extends above ground level and is shielded by the machinery, in contrast to the unsanitary open wells so common in India.

Proceeding now to the larger tube wells, the centrifugal pump is advantageous here, because of its capacity to move large volumes of water within the restricted space available inside a tube well. It is essentially a quick revolution machine which may be coupled direct to an electric motor. The reciprocating pump is cumbersome when designed for large volumes.

The term borehole pump has been applied to vertical spindle pumps which are of external dimensions small enough to go down a tube well. Two kinds are recognized; the centrifugal, and the axial flow propeller type; the former is preferred by the writer because of its lower power consumption.

The design of such pumps presents great difficulty. The hydraulic efficiency must be high and the output large in relation to the outside diameter of the pump; a 7″ pump of this type measures only $13\frac{3}{4}$ in. over the casing, a $3\frac{1}{2}$″ pump measures $8\frac{3}{4}$ in., the efficiencies being 65 per cent. and 55 per cent. respectively when used for the low lifts met with in irrigation, although better efficiencies are obtained with high lifts for town water service.

$3\frac{1}{2}$ inches, 4 inches, 5 inches, 7 inches, corresponding to outputs ranging from 0·3 cusec to 2·5 cusecs, are the sizes most useful for irrigation. A one cusec pump absorbs $7\frac{1}{2}$ horsepower for 40 feet lift, and a two cusec pump absorbs 14 horsepower. The smallest of the series absorbs only 2·8 horsepower to raise 0·35 cusec through 40 feet. A lift of 40 feet has been chosen to illustrate the performance of this type

of pump, because 40 feet is a very usual lift made up as follows, spring water 22 feet below ground, infiltration head 14 feet, lift above ground 4 feet, to command the area to be irrigated.

Borehole pumps comprise both the pump itself and the suction and delivery pipes. The figures of efficiency and horsepower quoted above relate to what is called commercial efficiency. All frictional losses in the piping have been included in the statement. Misunderstanding sometimes arises as to what is really meant by the efficiency of a centrifugal pump unless the horsepower is definitely stated.

As will be seen in Figs. 10 and 11, the drive may be electric, or by belt from an oil engine through a self-lubricated, dust proof gear box. The machinery is all situated above ground and readily accessible. The pump is submerged in order that the yield of the well may be maintained at the driest season of the year.

It will be noticed that the disposition of the well and pump is such that a perfectly sanitary supply is assured. A part or the whole of the water issuing from the pump may be safely used for domestic purposes, if required.

Reference has not yet been made to the details of construction of the tube well strainer, that portion of the well through which the water enters the tube after leaving the sands of the sub-soil. Sands deposited by sedimentation are fine in texture, generally so fine that a slit 25 thousands of an inch wide will permit a stream of sand to run through as in an hour glass.

All modern tube well strainers are virtually slitted tubes. Experience has indicated that slits 15 thousands wide will exclude all sands met with in practice, and yet allow ample room for water to enter. The writer has tried many different widths of slit to discover which is most satisfactory. The 15 thousands slit serves all general purposes, and no increase of yield occurs with wider slits as might be supposed. The danger with slits too wide is that sand may run in with the water, blocking up the tube, and eventually causing settlement and loss of the whole well.

A tube well strainer must be strong enough to withstand the compressive forces produced by the closure of the sub-soil upon it, and sufficiently rigid to resist any tendency to cripple under vertical loading, a condition that is present before the sub-soil has consolidated and firmly gripped the well. The interior of the strainer tube should, moreover, be smooth to minimise the friction opposing the passage of water through it.

The cheaper kinds of strainer tube lack one or the other of these qualities. Circumferential strength may have been sacrificed to save the cost of brass or copper composing the slitted envelope. Collapse under earth pressure has often taken place in these circumstances. Insufficient strength and rigidity at the joints between the separate lengths of strainer tube has given rise to buckling and crippling, followed by sand leakage and loss of the well. Some makes of strainer tube appear to be designed with the express purpose of creating as much hydraulic friction as possible, instead of the reverse. When choosing a strainer tube, it should be remembered that excessive friction causes the infiltration head at the bottom

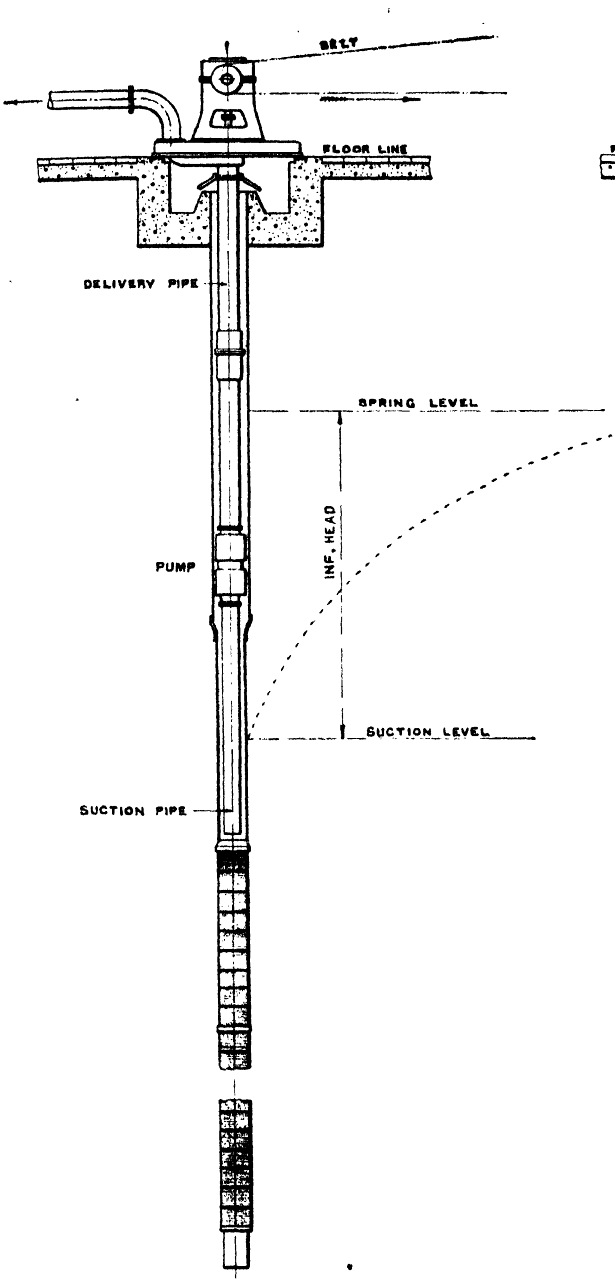

BELT
FLOOR LINE
DELIVERY PIPE
SPRING LEVEL
INF. HEAD
PUMP
SUCTION LEVEL
SUCTION PIPE

FIG. 10

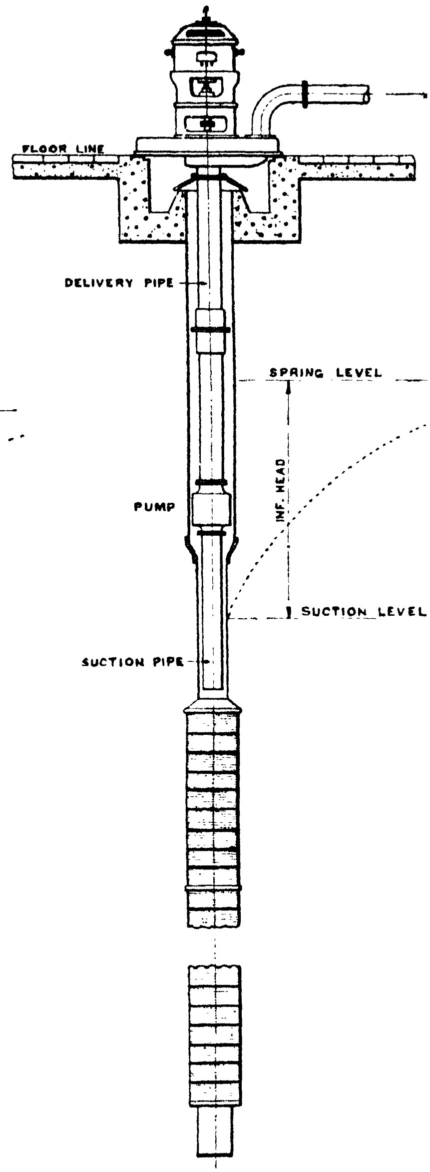

FLOOR LINE
DELIVERY PIPE
SPRING LEVEL
INF. HEAD
PUMP
SUCTION LEVEL
SUCTION PIPE

FIG. 11

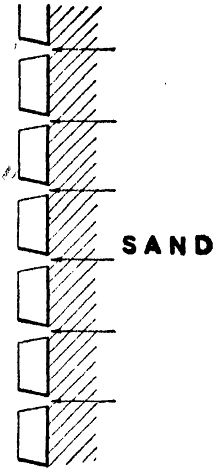


FIG.12

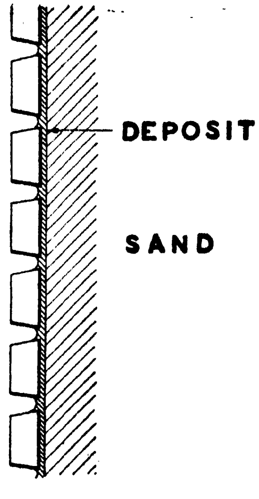


FIG.13

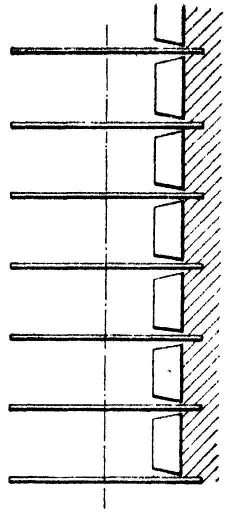
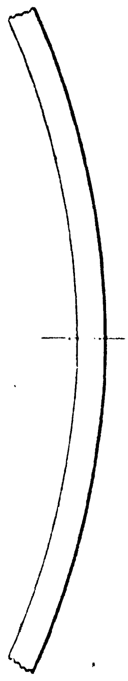
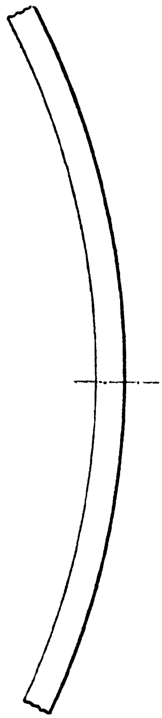
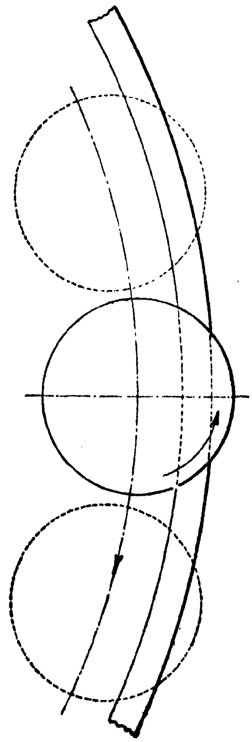


FIG.14







end of the well to be less than the measured infiltration head at the top of the well. An examination of a 2 cusec well 300 feet deep in service disclosed an infiltration head of 14 feet at the top and 8 feet at the bottom, a state of affairs corresponding to a loss of 20 per cent. in yield.

Strainer tubes are made in various sizes, to suit the great variety of sub-soil conditions existing in India. If the spring water table is low and the sand strata separated by thick deposits of clay, a deep well is necessary, which usually means one of small bore to economise in sinking expenses.

For irrigation, a large bore and comparatively shallow well is preferable; for example a 20-inch well 100 feet deep is likely to be superior to a 10-inch well 200 feet deep, although both possess the same area of surface.

The standard sizes of strainer tubes are 8 inches, 10 inches, 12 inches, 16 inches and 20 inches, measured over the actual slitted part of the tube. Nominal sizes as listed by some manufactures may not confirm to specification. A nominal 10 inch may be really 9½ inches. Nothing smaller than 8 inches is ever required for irrigation, even when the discharge is as low as ⅛ cusec.

We now come to a question which has exercised the minds of engineers for years, a question of concern for users of tube wells, which briefly stated is, will a tube well maintain the yield it gives when new ?

The answer to this question is no; a gradual decline will take place, determined by factors which will now be explained, a decline which is fortunately not rapid in certain cases, but still a decline to be reckoned with and for which a cure has been discovered.

Underground water is hard, due to salts of magnesia, lime and other substances contained therein. The sub-soil is composed of silica, alumina, and other materials which combine with the water to form a film of limestone and clay upon the surface of the strainer tube, gradually covering the slits and preventing the ingress of water.

This process, like many other chemical changes, is slow in its early stages, but as the film grows in thickness and bridges over the slits, the restriction to the entry of water becomes more pronounced, the last phase being a total closure of the slits and the cessation of water yield.

Fig. 12 shows a portion of the envelope of a tube well when new and clean. Fig. 13 shows the same tube with an impervious film upon it. A ten years' growth of film is quite thin, about the thickness and appearance of stout brown paper. Chemical analysis of a sample of film scraped from an all-brass strainer tube confirms that it is limestone mixed with clay.

The remedy for this condition, so adverse to the extension of tube wells, is really a simple one. The film must be removed or cut away. Fig. 14 shows how this is done. Each slit is provided with a disc cutter protruding beyond the surface of the strainer tube to cut through the film and clear away any deposit in the slits. As will be seen from Fig. 16, a series of cutters are mounted on a frame, and rotation of this frame or cage conveys motion to the cutters, which progress along the slits

much in the same manner as a disc plough advances through the earth of a field, breaking through the film and opening up the slits to their normal width, thus restoring the yield of the well.

This class of strainer tube has already been extensively employed and proved to be the solution to the problem of choking. A trial with it at one situation where ordinary strainers choked in three years has established the efficiency of the cleaning discs and their suitability for the purpose intended. It bears the name of the writer and is known as the Leggett cleanable tube well.

Fig. 15 illustrates a non-cleanable well, made from a plain slitted brass tube, with screwed couplings between the sections. Fig. 16 shows the interior of the cleanable well. The strong steel central tube will be noticed and the substantial form of coupling ; the slitted straining envelope is cut from solid brass and supported by the bars of the cages, and collapse under earth pressure is unlikely.

To conclude this article, examples of cost for irrigating lands with the appliances described are appended, the figures being taken from actual practice.

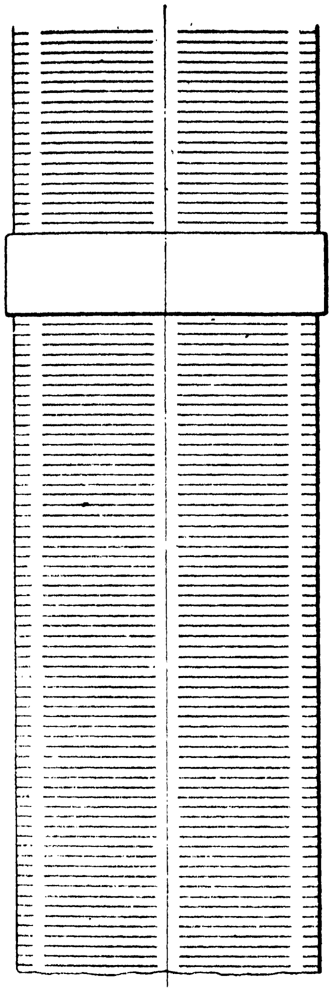
1. COST OF SMALL TUBE WELL INSTALLATION FOR 30 ACRES PER ANNUM, RECIPROCATING PUMP, OIL ENGINE DRIVE.

Data.

Spring water level 35 feet below ground.
Infiltration head, 12 feet.
Total lift from water in well to discharge pipe, 50 feet.
Quantity lifted $\frac{1}{8}$ cusec (47 gallons per minute).
Strainer tube, 10′ of 8″ Leggett cleanable type.
Pump, submerged reciprocating pattern.
Fig. 9, driven by an oil engine.

Capital expenditure.

	Rs.
Sinking charges to depth of 60 feet	300
10 feet of 8 inches cleanable strainer, with joints	500
Plain 7 inches pipe above strainer to ground level	160
Belt driven reciprocating pump to go down a 7″ pipe, complete with self lubricated geared head and discharge pipe, power absorbed 1 H. P.	1,100
Oil engine to burn kerosine, nominal output $1\frac{1}{2}$ B. H. P., complete with belt pulley and belt	350
Foundation for pump and engine	40
Fitting and starting to work	60
	2,510



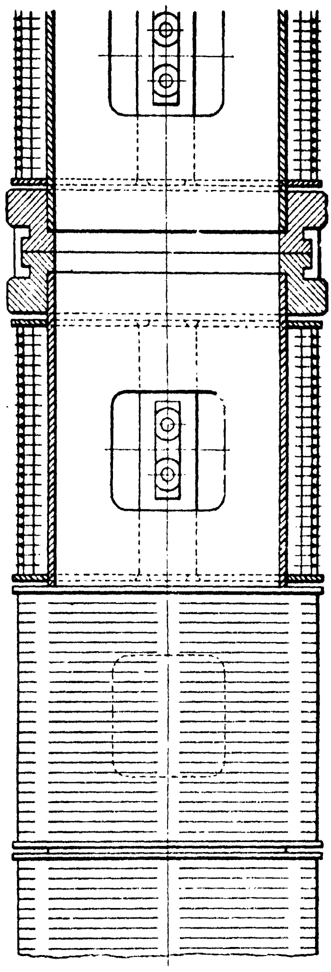
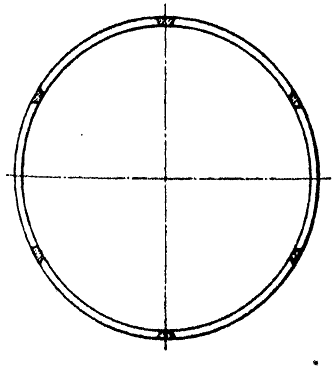
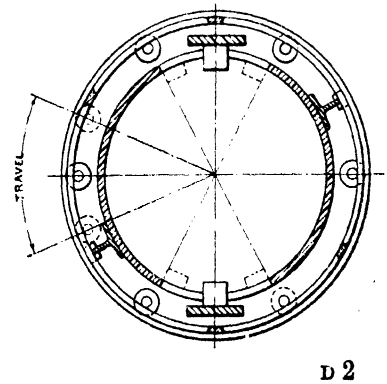


FIG. 15

FIG. 16





Running expenses.

	Rs.
200 days per annum, 16 hours a day, 10 hours per gallon for 1 B. H. P., cost of kerosine oil per annum	250
Depreciation at 5 per cent. on capital cost	125
Maintenance and repairs	60
Lubricating oil and small stores	40
	475

$\frac{\text{Rs. } 475}{30 \text{ acres}}$ represents Rs. 16 per acre.

2. Cost of tube well installation for 90 acres per annum, borehole pump, oil engine drive.

Data.

Spring water level 22 feet below ground.

Infiltration head, 14 feet.

Total lift from water in well to discharge pipe, 40 feet.

Quantity lifted, 0·35 cusec (130 gallons per minute).

Strainer tube, 24 feet of 8 inches Leggett cleanable type.

Pump, submerged borehole pattern, Fig. 10, with gear box for belt drive from an oil engine.

Capital expenditure.

	Rs.
Sinking charges to depth of 70 feet	420
24 feet of 8 inches cleanable strainer, with joints	1,200
Plain 9 inches pipe from strainer to ground	220
Belt driven borehole pump to go down a 9-inch pipe, complete with self-lubricated geared head and discharge pipe	
Quantity 0·35 cusec through 40 feet, power absorbed 3 H. P.	2,500
Oil engine to burn heavy oil, nominal output 5 B. H. P., complete with belt pulley and belt	1,800
Foundation for pump and engine	60
Fitting and starting to work	60
	6,260

Running expenses.

	Rs.
200 days per annum, 24 hours a day, 6 lb. of fuel per B. H. P. hour, at Rs. 130 per ton. Annual cost of fuel	500
Depreciation at 5 per cent. on capital cost	310
Maintenance and repairs	100
Lubricating oil and small stores	100
Wages of attendant	120
	1,120

$\frac{\text{Rs. } 1{,}120}{90 \text{ acres}}$ represents Rs. 12·5 per acre.

3. Cost of tube well installation for 250 acres per annum, borehole pump, oil engine drive.

Data.

Spring level 22 feet below ground.

Infiltration head, 14 feet.

Total lift from water in well to discharge pipe, 40 feet.

Quantity lifted, 1 cusec (375 gallons per minute).

Strainer tube, 72 feet of 12 inches Leggett cleanable type.

Pump, submerged borehole pattern, Fig. 10, with gear box for belt drive from an oil engine.

Capital expenditure.

	Rs.
Sinking charges to depth of 130 feet	1,170
72 feet of 12 inches cleanable strainer, with joints	5,000
Plain 9 inches and 12 inches piping from strainer to ground	500
Belt driven borehole pump to go down a 12 inches pipe, complete with self-lubricated geared head and discharge pipe. Quantity 1 cusec through 40 feet, power absorbed 9 H. P.	3,900
Oil engine to burn heavy oil, nominal output 12 B. H. P. complete with belt pulley and belt	3,000
Foundation for pump and engine	100
Fitting and starting to work	120
	13,790

Running expenses.

	Rs.
200 days per annum, 24 hours a day, 0·55 lb. of fuel oil per B. H. P. hour, at Rs. 130 per ton. Annual cost of fuel	1,380
Depreciation at 5 per cent on capital cost	690
Maintenance and repairs	280
Lubricating oil and stores	200
Annual wages of attendant	400
	2,950

$\frac{\text{Rs. } 2{,}950}{250 \text{ acres}}$ represents Rs. 11·5 per acre.

4. Cost of tube well installation for 500 acres per annum borehole pump, vertical electric motor drive.

Data.

Spring water level 22 feet below ground.

Infiltration head, 14 feet.

Total lift from water in well to discharge pipe, 40 feet.

Quantity lifted 2 cusecs, (750 gallons per minute).

Strainer tube, 88 feet of 20 inches Leggett cleanable type.

Pump, submerged borehole pattern, Fig. 11, with bedplate and stand for electric motor drive.

Capital expenditure.

	Rs.
Sinking charges to depth of 150 feet	1,650
88 feet of 20 inches cleanable strainer, with joints	10,560
Plain 12 inches and 18 inches piping from strainer to ground level	1,000
Vertical motor driven borehole pump to go down and 18 inches pipe, complete with bedplate, motor stand, thrust bearing and discharge pipe. Quantity 2 cusecs through 40 feet, power absorbed 14 H. P.	3,400
Vertical electric motor, 15 H. P., with starter and cables to motor	1,800
Foundations for pump	100
Fitting and starting to work	220
	18,730

Running expenses.

	Rs.
200 days per annum, 24 hours a day, 12 Kilowatts at one anna per K. W. hour. Annual cost of electric power	3,600
Depreciation at 5 per cent. on capital cost	935
Maintenance and repairs	350
Lubricating oil and stores	50
Part wages of attendant	240
	5,175

$\frac{\text{Rs. } 5,175}{500 \text{ Acres}}$ represents Rs. 10·0 per acre.

NOTE. The cost of electric energy is the main item in this example. If the charge per unit is reduced to $\frac{3}{4}$ anna, the cost of irrigation per acre drops to Rs. 8·5.

THE INDIAN AGRICULTURAL PROBLEM.*

BY

W. H. MORELAND, C.S.I., C.I.E., B.A., LL.B.,

Director of Land Records and Agriculture, United Provinces, 1898—1912.

(Concluded from Vol. XXIII, Pt. 5, pp. 369—382.)

IX. Mass education.

By education I do not mean teaching children in schools, but this topic requires mention, because in India it is commonly taken as a soporific drug; worthy gentlemen, roused for a moment to a sense of the problem of Indian poverty, are apt, in my experience, to murmur the word "education," and then fold their hands again to slumber, satisfied that the problem has been disposed of for their generation. My position in the matter is that, while a universal system of rural education of children is obviously indispensable for the future, it is irrelevant to the main task of the Commission, because it cannot affect the present situation; there is apprently nothing of the sort worth having in India to-day, and if there were, it would not begin to operate on rural mentality for another 20 years or so.

I left India with the conclusion that the rural primary instruction with which I was familiar constituted a grave potential danger. So far as it had any effect, it was to divert brains and energy from the land, which wanted them, to the towns, which had no work for them; and the system was, in fact, innocuous only because it was ineffective. A substantially similar view was expressed in the Quinquennial Review of Education for 1917, which reached the conclusion that the whole question was one for experiment. The remarkable Report of the Missionary Commission (*Village Education in India*, H. Milford, 1920, page 27) set down the failure of the system as too well established to require argument; the Quinquennial Review for 1922 disclosed no material change, nor have I noticed one in any later publication; so India has apparently still to take the first steps towards a proper system, under which the ordinary village children would leave school "content to be peasants, but determined to be better peasants than their fathers." I submit to the Commission that any system which depletes the villages of lads above the average of capacity is a system to be summarily eradicated in the interests of the whole country; the "drift to the towns" is likely to be at least sufficiently fostered by social conditions without spending money to inculcate it on the rural population in the mass.

*Memorandum for the Royal Commission on Agriculture in India.

Even, however, if an effective system of rural education could be introduced at once, a long time would be required before it could affect the mentality of the villages. The tone of village life is set by the elder peasants, not by lads of 14; at first, many of these lads will probably relapse, and it is only by slow degrees that those who have benefited most by their school years will come to play an active part. There are, indeed, some reasons for holding that an effective system of rural education of children will be the result, rather than the cause, of such a change in peasant-mentality as is required. In the Quinquennial Review for 1917, Sharp reached the conclusion that the future of education depended on the economic progress of the country, and there are familiar cases in America and other progressive countries where individuals or communities desiring education have set to work first to earn the money wherewith to pay for it. In the India of to-day it is difficult to see how the money could be provided for an effective system of rural education; it is not difficult to foresee a time when peasants will be ready to pay—whether in taxes, rates or fees is immaterial—for a thing which they realize is essential.

My present argument, however, is merely that effective rural schools, if they could be provided, would not meet the present need. The case is altogether different with the movement towards adult education, which received so much attention in the Quinquennial Review for 1922, and which is described by Darling in the book already quoted. The spectacle of grey-haired peasants sitting down eagerly to learn the alphabet is, to my mind, nearly the most inspiring thing that can be seen just now in all India; but, again, it does not point directly to a practical policy, because it indicates that the desired change in mentality is already in progress, that the secular inhibition is breaking up, and that the peasants in question are reaching out their hands to take what is offered. It is thus a movement to be fostered in every possible way, but it must be regarded as an effect rather than a cause; you cannot start adult schools except by convincing adults that it is worth their while to come.

Apart from adult schools, India already possesses, or can readily obtain, the institutions which in other countries have, or might have, contributed to adult education in the mass, and so paved the way for the education of children. The railways and the post office, newspapers and elections, gramophones, films, and wireless telephony, all these and others are, or can be made, available, while pilgrimages and the habit of looking for temporary work in distant places are perhaps more effective in India than elsewhere. I do not propose to examine the actual or possible utilization of these assets, because their discussion can best be carried on in India, but I think it is desirable to lay stress on the fact that in regard to all of them the Indian educated classes hold the key of the position, and I suggest that the Commission will find that, at the present juncture, a most effective attack on the problem of national poverty can be made in the sector of higher education.

Forty years ago Marshall, in his inaugural lecture, described his ambition "to increase the numbers of those whom Cambridge, the great mother of strong men, sends out into the world with cool heads but warm hearts, willing to give some, at least, of their best powers to grappling with the social suffering around them; resolved not to rest content till they have done what in them lies to discover how far it is possible to open up to all the material means of a refined and noble life". That sentence seems to me to furnish the outline of a policy deserving the Commission's best attention.

X. Mobilising the Intelligentzia.

I apprehend that the Commission will meet many Indian gentlemen who are unconscious of the cleavage which exists between town and country. That unconscious ignorance has to be dissipated, and that cleavage has to be bridged before the objects of the Commission can be fully attained. The northern peasant, as I know him, looks on townsmen in the mass as potential, if not actual, exploiters and oppressors; his attitude towards them is a combination of fear, mistrust, and hate; his chief line of defence is secrecy regarding his own affairs, combined with a servility in their presence which is in striking contrast to the language he uses behind their backs. There is nothing peculiar to India in this, for a similar attitude is a commonplace of peasant-literature, and in India it is explained, perhaps justified, by the history of the past; but the point is that the Indian peasant has been remarkably successful in keeping the towns in ignorance.

Twenty years ago the ignorance of the towns was complacent, but a change is now in progress. I have no opportunities of meeting Indian students in the mass, but I see samples of the best of them, who come to England for advanced study, and my observations of them may be summarised by saying that, while the ignorance still exists, there is now a new desire to know, and knowing, to help. The same features can be observed in the increasing volume of economic literature which reaches me from India, and I suggest that there is here a new spirit which the Commission can press into its service, and which, when once it is harnessed, will do increasingly effective work.

There is, I think, a need both for new special courses and for a new inspiration in the existing University curricula. I take the former first, and suggest the establishment of schools of what may fairly be called rural economics. The term is indeed liable to misconception, because in England, to which it belongs, it connotes capitalist-farming, whereas in India we are concerned with peasants; but in this matter, as in some others, I hope India will be able to escape from the trammels of terminology, and I see that the term has been adopted by at least one Indian University, so I use it in preference to peasant economics, which would describe my meaning more precisely. The curriculum of such a school would comprise various branches. First, there would be a study of the classical economic analysis, sufficient

to ensure that the student should be able to handle it effectively as an organ of research, or in more popular language as a box of tools, tools which are very sharp and dangerous to the inexpert worker, as so much modern literature shows. Next, there would be a comparative study of peasant life in other countries, directed to bring out those features of peasant-mentality which are common to all. Next, there would be the history of the Indian peasant ; I recognize it has still to be written, but adequate materials are available for a sufficient period. Finally, there would be the study of the peasant in his present environment, going into increasing detail for selected areas, a province, a district, a pargana, and a few individual villages, and utilizing to the fullest extent the stores of official records which are now so little studied, not merely the Gazetteers and Settlement Reports, but more definitely technical records, such as the rent-rate reports and the village assessment statements themselves.

It appears to me that such special schools would be entirely appropriate features in the Universities of a peasant country, and that here the Commission can give a valuable lead ; but in any case I suggest that a fully-equipped school of the kind should be an integral portion of any Staff College which the Central Government may maintain for training agricultural officers at Pusa or elsewhere ; the course need not necessarily be made compulsory, but there should be a definite rule that, after a reasonable interval, the selection for the higher administrative posts in the agricultural and allied departments would be confined to officers who had qualified in rural economics, either at a University or at the Staff College, thus meeting the need which I have indicated in section III of this memorandum, and recognizing that in this branch of activity, rural economics is the master-science, and not a mere accomplishment.

At the moment, however, I am more concerned for action on the mass of University students, and it is here that I believe a lead from the Commission will produce the best results in the shortest time, because it will affect all the various instruments of mass-education. We are concerned with the courses in history and in economics, which, taken together, are now the chief medium of higher education ; in regard to them I will outline what I take to be the ideal, realizing that it cannot be attained all at once, but confident that each step taken in the right direction will give concrete results immediately, and will make the next step easier.

My ideal of a course of Indian history for Indian students, whether pass-men or honours-men, is that the peasant should be given a place in the centre of the stage throughout the period when anything can be learned about him. The history of the last six centuries, as it is now taught, deals with the achievements of a long line of great men—nearly all of them foreigners—from Alauddin, the illiterate Turk, to Curzon, the English aristocrat. Let the ordinary undergraduate learn what the peasant meant to these men, and what they meant to the peasant ; let him learn further the significance from this point of view of names now more rarely heard in the schools, from Ghiyasuddin Tughlaq to Jonathan Duncan, the men

who made the peasant their first care ; let him see the peasant through the centuries under the influence of the forces which have made him what he is, and he will go out into the world infinitely better equipped than now to take a share, perhaps an unconscious share, in the work of mass-education, whether he becomes doctor or lawyer, journalist or official, landholder or politician.

In economics, as in history, the peasant has to be brought forward to the centre of the stage. It was inevitable that economics teaching in India should draw its initial inspiration from England, but, at the same time, it was unfortunate, because doctrine elaborated in an atmosphere of large-scale industry, world-commerce and international finance is apt to repel Indians, not by its intrinsic content, but by its exotic accidents. The quaint idea of a separate science of "Indian economics", which had a short vogue recently, was an expression of this natural repulsion ; but the remedy lies, not in creating a new science, but in presenting the existing science in more familiar garb, "in terms of the Indian field and market-place", rather than in terms of Birmingham and Liverpool, of Lombard Street and Mincing Lane. In such a presentation, the peasant will naturally occupy the most prominent place ; and students who have approached the science by this road will be in the best position to join effectively in the fight against national poverty.

XI. Supplementary considerations.

The ideals which I have sketched so briefly may be regarded as furnishing the strategical outline of the attack in this sector, an attack by the massed forces of the educated youth of the nation, but the outline requires to be supplemented by a few considerations of a tactical nature. In the first place, the change, or rather the enrichment, suggested in the courses in Indian history is in the direction of a movement already in progress. The branches of the study known as social and economic history are almost everywhere gaining ground at the expense of political history, which is now regarded rather as the skeleton of the subject, essential of course, but needing to be clothed with flesh and blood in order to furnish a just and adequate presentment of the past. Comparison of courses of study prescribed at different dates indicates that this movement is already in progress in Indian Universities, and suggests that the present need is not to change the direction of the current, but to strengthen it and to concentrate it on the peasant as the most important subject. Similarly, the ordinary courses in economics are already changing in the desired direction, and inspiration such as the Commission is in a position to give will contribute force to an actual movement rather than initiate a new departure.

Again, it is important to recognize the value of youth in this matter. I have said above that the schoolboy cannot count for much in the village, but the young graduate counts for very much in the town, and is, in fact, one of the chief agents in spreading new ideas among the older generation. At the present juncture

young men have a chance such as they have not hitherto enjoyed in India; the Commission will, I expect, be struck by the youth of witnesses occupying high positions in the academic world, and it is scarcely an exaggeration to say that ideas absorbed during the ordinary courses of study may pass into general circulation without delay. The suggested line of action thus promises speedy results in a case where time is of the essence of the problem. Opposition to it may be expected chiefly from the older men, many—but by no means all—of whom are affected by the intellectual inertia, which is perhaps as common in India as in other countries. For such men there is a great attraction in well-established courses, with text-books and lecture-notes proved by experience to be suitable; and, in the case of over-worked teachers, there is a natural reluctance to break fresh ground, search unfamiliar sources of information, and remodel machinery which is running smoothly. It is quite possible that the most vigorous pioneers on the lines I have suggested will be found in the younger Universities of the north, which have still to justify their existence before the academic world, but, as it seems to me, there is quite enough energy in the older foundations to justify the hope that they, or some of them, will play their part.

Finally, the most hopeful feature in the situation is the widespread and increasing anxiety which exists regarding the future of the country. The classes usually grouped under the label "intelligentzia" are filled with worthy and lofty, if vague, aspirations, but at every step on the way towards realization they run against the barrier of the national poverty; in their anxiety to surmount it, they are ready to listen to every charlatan and to try every quack's prescription; what they have not yet done is to study the problem seriously and as a whole. My suggestion is that the Commission will find its opportunity in this situation, and that by its published opinions, and still more perhaps by its examination of representative witnesses, it can bring the light that is wanted into this obscurity. The national poverty is in essence the peasant question, for in India at least it is true that *pauvres paysans font pauvre royaume;* it can be attacked successfully only by working with, and for, the peasant, and accurate knowledge of the peasant is the first condition of success for the great body of the intelligentzia, which, in one phase or another, must bear the brunt of the struggle. A realization of these truths and a determination to apply their lessons are, so far as I can see, the most effective forces which can be brought into play.

XII. Increase of rural income.

I had intended to bring my remarks to a conclusion at this point, but it has been suggested to me that I should amplify what I have said in the opening section, to the effect that, while agriculture must play the most prominent part in the struggle with poverty, it cannot hope to win without the co-operation of its allies. Accordingly, I attempt in this section to indicate what seem to me the main lines of advance in somewhat greater detail.

In my view, India must continue to be in the main a peasant country. In places there may be room for the ranching, or plantation, system, and almost all over the country there may be room for a proportion of large farms worked by capitalists, but the degradation of the mass of peasants to the status of hired labourers seems to me to be as impossible in practice as it is socially undesirable. It follows that the industry will normally be confronted by that group of stubborn physical facts which economists have labelled the law of diminishing returns, and that there will always be need for expert departments engaged in pioneering those progressive improvements in the arts of agriculture by which alone the barrier can be gradually thrust back. This statement sounds like a truism, but it is a truism worth repeating, because in India there is still a body of opinion which holds that agriculture can be brought up to date once for all, and which does not recognize the necessity for continuous progress. It is worthwhile then to insist on the fact that what Indian agriculture needs is not so much change as flexibility and continuous adaptation to the progress of knowledge on the one hand and to the conditions of the markets on the other.

Looking then to a process of evolution rather than a revolutionary change, a large increase in the net income of the country involves both an increase in gross income and a reduction in cost by the elimination of waste. So far as I can judge, the first process alone cannot suffice, but must be reinforced by the second, if the economic position is to be materially improved.

As far as the fully-occupied country is concerned, I have nothing to say on the problem of increasing the gross income, beyond repeating that it is being handled by the technical departments on lines which experience has shown to be generally sound. Where large tracts of land are either uncultivated or seriously under-cultivated, the cause is usually either want of water for irrigation or else unhealthiness. The great irrigation projects recently carried out, or now in progress, probably leave comparatively little to be done under the first head, and that little will be done by degrees. Under the second head, the position is that the recent spectacular advances in knowledge have carried sanitary science for the moment far ahead of the possibilities of practice. Something can often be done to provide drinking water where this is bad or lacking, but the effective control of specific diseases such as malaria must, I fear, wait for the development of the will to live better, because it depends on the hearty co-operation of the people affected; and in regard to some of these tracts, the question may arise whether it would not be more profitable to hand them over to the Forest Department in cases where the existing population can be otherwise provided for. The question is, however, of minor importance, though it is not negligible; the main source of increased gross income must be the land, which is already more or less fully occupied.

As regards elimination of waste, we have to distinguish the material factors of production, land and capital, from the human factors, management and labour. The greatest source of waste in regard to land is, I think, the unsatisfactory arrange-

ment of holdings, with numerous small plots scattered over a large area ; the evils of this arrangement are now so notorious that I need not enumerate them. When I first ventilated the subject nearly 20 years ago, my tentative proposals were given decent burial, in the traditional Indian fashion, under a mass of *à priori* objections, but the experimental success recently attained in the Punjab satisfactorily disposes of all those objections except one, and they need not be considered further. The exception is the difficulty that fragmentation by inheritance has a religious sanction, so that consolidation is exhibited as, at the best, a temporary improvement, according to some critics not worth the trouble of effecting, because the effect will be so shortlived. It will be recalled that a similar objection was advanced less than a century ago against the equipment of railways for passenger traffic ; it was almost universally agreed—beforehand—that Hindus of all except the very lowest classes were absolutely prevented by their religion from travelling by rail, and it was argued that no great passenger traffic could be expected ; but the railways were made, and the people used them. I suggest, then, that the *à priori* objection need not deter the Commission from pressing on this essential reform. Let the people see what compact holdings mean in actual working ; let them enjoy the experience for a generation, during which the will to live better is likely to be a constantly increasing force ; and let them in the end adjust the religious difficulty for themselves, or ask their Legislature to do it for them.

To the economist land includes water, and it may be well to say a few words regarding its waste. The provision of water where it is needed for irrigation has long been recognized as the greatest improvement possible, and has gone far ahead of the study of economy in utilization. The waste in the application of canal-water is a commonplace of the reports, while, in the case of wells, the quantity of water actually used often bears a disappointingly small proportion to what is raised ; economy in this matter will often operate to extend the area which can be irrigated from a given supply, and, in the case of wells, will mean also a valuable saving of time and power.

Turning from land to capital, it is indisputable that Indian peasants hold in gold and silver an amount of idle capital that is, in the aggregate, enormous ; leaving older accumulations out of account, the distribution of a large proportion of the recent huge imports of specie can be traced down to various agricultural tracts, from which there is no corresponding outflow. It is a question how much of this could profitably be put into the holdings under present circumstances, but there is no doubt that, given good business, whatever is not wanted for the holdings could be safely and profitably invested in securities in India, or, if necessary, in other countries, and that very large numbers of Indian peasants could thus come into line with those in France and elsewhere, who have a supplementary income from sources outside their main occupation. The results of such an investment would probably transform the whole financial position of the country, providing much cheaper capital for producers, and leading to a large increase in production ; the

conditions for its realization are, first, development of the will to live better, and second, very much better business than now exists. The new forms of small Government securities have had a spectacular success, but I have not yet been able to learn the extent to which they have attracted the peasants' idle reserves, and, in any case, there is more accumulated money in sight than the Government could utilize; so that there is here a clear case where the will to live better and the development of better business must go hand in hand.

The human factors to be considered are management and labour. In those parts of India which I know personally there is very great waste in the matter of management. You find a man with the energy and capacity required for working a large holding, crippled by inability to get the land, even though he takes subleases on ruinous terms; and alongside of him you find an incompetent slacker, starving on a holding which, if properly managed, would adequately supply his needs. Some such inequalities must, I suppose, always exist, but in India the waste is, in my judgment, far too great, and this is due mainly to the systems of tenure that have been established in the course of the last century. The Commission is, I know, debarred from making recommendations as to tenure, but the subject cannot be altogether avoided in an analysis such as I am attempting. The position, as I see it, is that, while in the nineteenth century security of tenure was undoubtedly the most important need, the effect of continued concentration on security has been to create a rigidity which involves serious economic waste; and what is now wanted is a greater degree of flexibility, with more scope for the good peasant to rise, and with speedier elimination of the bad peasant—who must always be eliminated in the end. The adjustments required to meet this need will necessarily vary with locality, and since the Commission can make no recommendations, I do not propose to say anything about them; my point is merely that at present there is very great waste, waste of land under bad management and waste of managing ability for want of access to land.

Probably, however, the greatest waste of all is the waste of labour. By labour I mean not merely wage-earners, but the entire agricultural population, including the peasant and his family, who live by results, and also the labourers and artisans who live by wages or dues. The present agricultural system involves short periods of overstrain and much longer periods of under-employment or even entire idleness; the agricultural population draws 12 months' livelihood from less—sometimes much less—than 12 months' work; the remainder of the year is almost totally lost, unless work can be found outside the village; and there is some reason to think that the longer spells of idleness have an injurious effect on character, reducing the quality of the work that is done in the short working season.

This waste is almost general, but its amount varies greatly with local conditions. The worst case is that of villages depending solely on the rains crops. In them the arrival of the monsoon brings a period of intense effort to get the maximum area sown, however poor the tillage, and to fight the weeds; there is often much

more to do than can be done thoroughly in July and August, but once the harvest is finished, say in November, there is practically nothing to be done till the next monsoon arrives. Contrast this with a village where either the qualities of the soil or the facilities for irrigation make winter cropping possible. A smaller area will be sown in the rains, but it will get much better tillage; the aggregate area in the two seasons will be substantially greater, and the yield more than proportionately so; the working season lasts for nine or ten months instead of four or five; the village can be worked by a smaller population, with less overstrain at the peak of the load; and the year's net income will be substantially larger, while the habit of continuous work will be established.

In parts of India which I know such villages are fairly common, but in some of them a further adaptation can be observed. The longer working season is yet not fully occupied, and there is a slack time from April to June; some of the best Oudh peasants use these opportunities to fit in a field of sugarcane, the cultivation of which can be made to dovetail admirably with the other crops, and such men may fairly be said to do an honest 12 months' work in the year, though necessarily there are idle days and hours. I mention this particular case because it can be generalised. The sugarcane crop in Oudh is best regarded as a labour savings-bank; the peasant puts into it days and hours of work which would otherwise be wasted, and he draws the value of his labour, often with exceedingly good interest, when he sells his produce; and, while the use of this particular savings-bank depends on local conditions, the need for similar facilities is almost universal.

One great aim of rural reformers should then be to eliminate the periods of overstrain, to spread work more evenly over the year, to diversify the cropping so as to provide regular employment, and thus, with the aid of suitable machinery, to produce a larger gross income by means of a substantially smaller population engaged in regular work. For the absorption of the surplus population, agriculture must depend on the development of industries, proceeding gradually and as nearly as possible at the same pace, so that the change-over may be as nearly painless as possible. In this connection it is necessary to allude to the location of factories, a topic that at first sight may seem somewhat remote. The "industrial centre" is now out of date, and in the West we speak rather of industrial districts grouped round commercial centres. In India I think this principle should be fully recognized and even extended; the ideal—not, of course, likely to be completely realized—is a factory at each railway station, drawing its main supply of labour from the surrounding villages, setting a standard of wages to which the villages must conform, and incidentally facilitating the introduction of machinery among a population now ignorant of the use of metals. The ideal is accepted in substance by experienced social workers such as Miss Broughton (now Lady Chatterjee), who concludes (*Labour in Indian Industries*, page 180) that the decentralization of industries, with the improvement of communications, is the only way of settling the industrial housing question so as to retain all the best features of village life; and in my

judgment the matter is one where the rural reformer and the social worker can wisely join hands, aiming at the widest possible diffusion of organized industries. At any rate, it may be hoped that nothing like Bombay will ever be allowed to happen again.

It must be recognized, however, that, even when the surplus population shall have found other means of livelihood, employment in agriculture can never be entirely regular; there will always be wet days and slack times, there will always be people unfitted for the hardest work, and thus there will always be room for cottage industries. This subject has been scarcely explored as yet in India, except by politicians and a few philanthropists. I do not know whether the Commission will undertake its study or will mark it off as requiring study by others; and I will say only that, more almost than any other reform, it involves very much better business than now exists in India, both in buying materials and in marketing finished goods. The aggregate of time available would probably suffice to yield a substantial addition to the national income, but the addition will not materialize until a fair share of it is assured to the workers, and this cannot happen in the present state of internal commerce.

XIII. The future.

In the foregoing section I have indicated as briefly as possible some of the main lines of rural improvement, and the nature of the co-operation which agriculture needs from outside. It may be worth while to look a little forward and see what the result is likely to be when the processes I have indicated shall have been going on for some time.

1. *The standard holding*, that is to say, the area (which of course varies with local conditions) which can be cultivated effectively by one team, such as the ordinary peasant can hope to possess. The standard holding, in this sense, will be definitely larger, but of the same order of magnitude as now. The increase will be rendered possible partly by better implements, partly by better animals, partly by a better system of cropping; its sources will be referred to below.

2. *The average holding* will be more than correspondingly greater because there will, I think, be a somewhat larger number of peasants with more than one team, while there may also be some large areas farmed on capitalistic lines. The increase will be obtained, to some extent, by the utilisation of fresh land, but mainly by eliminating a proportion of the existing smaller holdings. Here, however, I must enter a *caveat* against the common Indian view that it is either necessary or desirable to eliminate all the "uneconomic holdings", to use the current phrase. Large parts of England did that, and, in doing so, heedlessly destroyed the labourer's ladder; and those of us who have watched the prolonged and not over-successful efforts to reconstruct that ladder are bound to insist on the importance of maintaining it where it exists in India. The labourer with a field or two for his spare time, the

smallholder who works in his spare time for others, the peasant who works his holding unassisted, and the peasant who employs hired labour to help himself, there should always be room in India for all these classes. I have seen it asserted that such a "ladder" does not exist in India; it certainly exists in the country I know, for I have watched men mounting it in spite of obstacles arising out of the system of tenure; if it does not exist elsewhere, it will have to be constructed.

3. *The peasant's income.* The ordinary peasant, occupying a larger, more compact, and more conveniently situated holding, will get better crops than now, both in yield and in quality, and there will be fewer calls on his produce, so that his net income will be substantially increased; in addition, he will often have a supplementary income from securities and from some form of home industry. He will have more to sell and he will want to buy more. He will have access to much better markets than at present, and, with higher prices for sales and cheaper purchases, increased produce will go much further than now.

4. *Specialisation.* There will be certainly be more specialisation in cropping, each region growing what it can grow best. How far this process can be carried is uncertain, but it is quite possible that ordinary peasants will buy some of their staple food, as well as more fruit, vegetables, spices, and other adjuncts. In that case, one hopes they will not repeat the English mistake of giving the best part of the grain to the pigs, and keeping the starch for their children; at present home-grinding and home-baking constitute an important asset, securing the best results from the limited quantity of grain available for food.

The smallholder will almost certainly have to buy much of his food, devoting his land mainly to intensive culture of special crops, fruits, or vegetables for which he will find a market among his more substantial neighbours, besides having better access to the towns and, probably to preserving factories.

5. *The labourer*, influenced, like the peasant, by the will to live better, will be readier to change his employment, and, with a reasonable diffusion of organised industry, village wage-rates will be linked to urban, so that labourers, doing better work than now, can hope for their fair share of the increased income. It is reasonable to suppose that they will not lose the land-hunger which now affects them, and that—where a ladder exists—money earned in a factory will often go into a smallholding.

6. The volume of *internal trade* will be much larger and its course much more active, with a lower rate of profit on the larger turnover, and there will be—what now scarcely exists—scope for that productive and distributive energy which is so important a contributory factor in raising the standard of life.

7. The *export trade* in agricultural produce will not necessarily be increased in volume and is perhaps more likely to shrink; but, on the other hand, exports of manufactured goods will rise, while the investment of the country's idle capital will transform the whole monetary situation, and may even suffice to make India a creditor nation, so that the currency question will no longer cause anxiety.

8. When this stage has been reached by gradual development, the peasant will be the master of his future, and consequently of the future of the country. He will have made some progress in the arts of wise spending, of spending to earn and of saving now to spend later; and if, as I suspect will be the case, his strong family affections concentrate themselves on the preservation of the holding intact as the family property, with provision for dependants from invested savings, and with the understanding (by no means foreign to India) that the cadets shall usually carve out their own careers, the economic system will be at once stable and progressive.

XIV. Conclusion.

Development on the lines I have indicated will call for concentrated and persistent effort on the part of the entire nation, not merely the State Departments and the Legislatures, but the brains and the hearts of the people; but, so far as I can see, the driving-force, which must set the wheels in motion and carry them over the recurring dead-points, can be provided only by the will to live better, manifested increasingly among the rural population. And so I end where I began. The promotion of the welfare and prosperity of the rural population, in other words, the solution of the problem of national poverty, is, in its essence, a psychological question. The design of the machinery is, indeed, a matter of great importance, but without adequate driving-power, its outturn must be disappointing. The argument of this memorandum is briefly that India has now reached the stage where the machinery is in existence, not perfect or final, but adaptable and improvable without insuperable difficulty; the time has come for concentrating attention on the source of power.

RESEARCH IN COTTON TECHNOLOGY IN INDIA, 1927.

BY

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IV. The Standard Indian Cottons.*

At the beginning of the work in the Technological Laboratory it was necessary to adopt certain cottons as standards with which to compare any other cottons sent for test. Now one of the consequences of the research work of the Agricultural Departments during the past twenty years has been the isolation, development, and introduction into general cultivation of certain improved strains of cotton, and as the total area under these various improved types amounts at the present time to over three million acres, they have been adopted, in preference to the older but more variable commercial types, as standards with which to compare new cottons. These standards—there are 18 of them—have been tested in some cases for the past four seasons, and the results have been published in "Technological Reports on Standard Indian Cottons, 1927."

These reports have a value beyond that for which they were primarily intended, *viz.*, setting up standards with which to compare new types developed by cotton breeders. As pointed out in the introduction to the reports, economic considerations usually determine what price a cotton shall fetch, but where only small quantities of it are available or its intrinsic value is not fully appreciated, a new cotton may not receive its full value as compared with other cottons. Naturally, with the known difficulty of valuing a new type of cotton, a buyer tends to work on the safe side; he has no wish to buy a pig in a poke. It is therefore very evident that it is not sufficient merely to develop a new and improved strain. Difficult as this may be, it is probably much more difficult to bring the new type into large demand. It is clear that the publication of these Technological Reports, by widely advertising the merits of the cottons therein dealt with, is a step forward in the adequate marketing of these standard cottons.

It is probable that with the system in vogue at the Technological Laboratory rather better results are obtained from a cotton than can normally be expected in

*"Technological Reports on Standard Indian Cottons, 1927," Indian Central Cotton Committee Technological Laboratory, Bulletin No. 11, Technological Series No. 6, November 1927.

the mill. Although the Laboratory machinery is of the ordinary type, the plant as a whole is a small one, so that it is comparatively easy to keep it always in good condition, and expert supervision is readily maintained. It is not so easy to keep the machinery and operatives in an ordinary mill up to the same concert pitch. Still, full details are given in the reports of the speeds, settings, drafts, etc., used in the different spinning tests, together with full details of the results obtained. The various reports therefore indicate what a cotton *can* do under these conditions, and with a little experience a spinner should quickly be able to make the necessary allowances in arriving at a conclusion as to what he can expect the cotton to do in his own mill. The individual reports on the 18 standard Indian cottons, and 3 American cottons (tested for comparative purposes), are each divided into the following five sections :—

I. Agricultural Details;
II. Grader's Report;
III. Fibre Particulars;
IV. Spinning Tests;
V. Remarks.

The agricultural details provide some idea of the relation of the standard cotton to the commercial crop of the district, the history of its introduction, the soil and climatic conditions in which it is grown, and the magnitude of the crop of the new cotton. The Grader's report shows his estimate of various characters of commercial importance. The fibre particulars include the fibre-length, the fibre-length distribution (also shown graphically), the fibre-strength, the fibre-rigidity, the fibre-weight, the fibre-width, and the number of natural twists in the fibre. The "spinning tests" section comprises a description of the treatment given in the spinning machinery, the spinning master's report on the cotton, a yarn examination report for evenness and neppiness, together with a table of spinning test results, including the waste percentages, the ring frame particulars, the results of lea and single thread tests, and figures showing the physical conditions of temperature and humidity prevailing during the spinning and testing respectively. The "remarks" section briefly summarises the main conclusions which may be drawn from the results of the fibre-tests, the amount of waste made, the number of yarn breakages in the ring frame, and the results of the various tests and examinations to which the yarns are subjected—particularly with reference to the question of seasonal variation.

The following table gives the salient features of the standard Indian cottons. It will be seen that these cottons may be divided roughly into four classes: The first class comprises cottons which may normally be expected to be satisfactory for standard warp counts of 30's and over; the second class, cottons between 20's and 30's; the third class, cottons between 10's and 20's; and the fourth class, cottons which are only suitable for yarns below 10's.

TABLE I.

Showing details of Standard Indian Cottons.

Cotton	Botanical species	Province or State	Average Fibre-Length (inch). Sorters	Average Fibre-Length (inch). Grader	Highest standard counts	Approximate acreage under cultivation	Date of sowing	Picking period
Class I—Cottons.								
Dharwar 1	*G. herbaceum*	Bombay	0·89	0·94	34	300,000	Mid-August to the end of September.	Second week of February up to the middle of April.
Gadag 1	*G. hirsutum*	Do.	0·84	0·81	20/38	125,000	First week in September to first week in October.	Ditto.
Surat 1027 A. L. F.	*G. herbaceum*	Do.	0·98	1·00	26/32	200,000	Third week in June	From mid-March onwards.
285F.	*G. hirsutum*	Punjab	0·93	0·94	28/34	--	Last week in April to third week in May.	Second week of October up to the end of January.
289F.	*G. hirsutum*	Do.	0·99	1·06	30/38	10,000	First week of May up to end of May.	Third week of October up to the end of January.
C. A. 9	*G. hirsutum*	United Provinces	0·88	0·81	28/34	1,000	Third week of May	Early October to early December.
Co. 1 (Cambodia 295)	*G. hirsutum*	Madras	0·93	1·00	30/38	1,000*	Early October until early November.	March-April and July-August.
Nandyal 14	*G. indicum*	Do.	0·91	0·94	32/34	20,000	From the middle to the end of August.	January to April.
Class II—Cottons								
4F.	*G. hirsutum*	Punjab	0·80	0·87	22/24	1,000,000	First week in May up to the end of May.	Second week of October up to second week of January.
Hagari 25	*G. herbaceum*	Madras	0·84	0·75	24/28	160,000	From last week in August to the 1st week of September.	From the last week in February to the middle of April.
Karunganni C7	*G. indicum*	Do.	0·84	0·87	26	30,000	October	March—April and June—July.
Umri Bani	*G. indicum*	Hyderabad	0·83	0·75	22/24	1,700,000	June	October to December.
Class III—Cottons.								
Wagad 4	*G. herbaceum*	Bombay	0·82	0·75	14/16	50	Beginning of July	From March onwards.
Wagad 8	*G. herbaceum*	Do.	0·80	0·62	12/14	60	Ditto	Ditto.
K. 22	*Hybrid*	United Provinces	0·78	0·69	12	..	Third week of May	First week in October up to December.
J. N. 1	*G. neglectum Malvense.*	Do.	0·78	0·69	12/14	1,000	Early in June	Third week in September to end of November.
Class IV—Cottons.								
Mollisoni	*G. indicum Mollisoni.*	Punjab	0·70	0·62	6/8	90,000	First week in May up to the end of May.	First week in October up to last week in January.
A. 19	*G. neglectum roseum.*	United Provinces	0·70	0·56	6/8	30,000	Last week in May	First week in October up to the last week in November.

* The total irrigated Cambodia crop is about 113,000 bales.

The value of duplicate tests. At the Technological Laboratory it has always been the practice to carry out spinning tests on duplicate samples. A large number of such tests has now been made, and it is accordingly possible to analyse the results thereof and so obtain some idea of the value of these duplicate tests. The following analysis has been confined to the tests on the standard cottons for which the results are given in Technological Reports. In all, 263 sets of duplicates are available; these duplicates relate to many standard cottons, and a number of different counts. The various results have therefore been brought into line with one another for comparison purposes by expressing the difference between the count-strength products of the two duplicates of each set as a percentage of their mean.

The average difference between the count-strength products of duplicates was found to 5·1 per cent. The frequency distribution was as under :—

Frequency distribution of the differences between the count-strength products of duplicates.

Percentage difference between duplicates	Frequency	
	Actual	Percentage
0—2	69	26·2
2—4	60	22·8
4—6	42	16·0
6—8	31	11·8
8—10	26	9·9
10—12	15	5·7
12—14	8	3·0
14—16	3	1·1
16—18	7	2·7
18—20	2	0·8
TOTAL	263	100·0

From this frequency distribution, it will be seen that about half the results show a difference of not more than 4 per cent., and the other half show a difference exceeding 4 per cent. Moreover, in 13 per cent. of the cases, the difference between the duplicates is more than 10 per cent. These results show that a spinning test cannot be regarded as reliable if it is confined to a single test, with a spinning in one count only. They indicate too the necessity for some such procedure as that adopted at the Technological Laboratory by which any sample is divided into duplicate lots, each of which is spun into three different counts.

V. Spinning Tests on Small Samples.*

What is the minimum weight of cotton necessary for a trustworthy spinning test ? The average spinning master would probably reply—at least 100 lb. And where large supplies of the cotton are available, and it is desired to test the cotton under ordinary mill conditions and without special facilities, the practical man would doubtless be correct in his answer. But where special conditions and facilities do exist—as at the Technological Laboratory—it does not by any means follow that the same question demands the same answer. Indeed an elaborate investigation at the Technological Laboratory has now shown that it is possible to get very consistent results with samples weighing only 10 lb. The importance of the question lies in the fact that in the early stages of the development of a new strain 100 lb. of its lint simply do not exist, for the cotton breeder has to multiply a new strain during three seasons in order to obtain even a few pounds of lint. Yet he strongly desires to have a spinning test made on a sample at the earliest stage possible, because at the present time the spinning test affords the only reliable guide to the quality of the cotton. Moreover, a cotton breeder grows a number of strains at one time ; he has neither the time nor the staff nor the land available for growing large quantities of all his strains. At a certain stage, therefore, he cannot continue to multiply all of them ; circumstances compel him to select some and to reject the others. Evidently his work will be very much facilitated if a reasonably accurate spinning test of his cotton can be made when only about 10 lb. of lint of any given strain are available, and he will be correspondingly hampered if he is asked to provide at least 100 lb. of lint for the spinning test.

It has already been pointed out that the spinning test result by itself is not sufficient to enable the cotton breeder to decide whether to retain or to reject any given strain, because, from the agricultural standpoint, the ultimate test of any variety is the average monetary return which it yields per acre under perfect marketing conditions, and this involves two main factors, *viz.*, the yield of ginned cotton per acre, and the quality of the lint. These two factors themselves depend on a number of plant characters, many of which are imperfectly understood, so that extended field tests are necessary before any variety can be brought to the notice of cultivators. In these circumstances the value of the spinning test lies in the help it affords the breeder when at the end of a season he classifies his strains into :—(1) Strains worth multiplying and extended field-testing ; (2) strains worth further study ; (3) strains not worth multiplying. By acting in accordance with this classification in the following season he will obtain for the spinning tests larger quantities of the cottons of class (1) ; he will simply maintain and not multiply the cottons of classes (2) and (3), and so even of these he will obtain sufficient lint to allow of further small-sample spinning tests, the results of which will serve to check

*"Technological Reports on Standard Indian Cottons, 1923-26," Indian Central Cotton Committee Technological Laboratory, Bulletin No. 7, Technological Series No. 3, May 1927.

the conclusions for the previous season's crops. It is important to notice that no final decision as to the fate of any given type would be based on the results of a spinning test on 10 lb. weight of cotton lint of a single season. The whole question therefore resolves itself into this: Are the results from tests on a 10 lb. sample of cotton sufficiently trustworthy to be used as a guide in the manner described above? In order to answer this question most of the standard cottons were tested in six different lots having the following initial weights: 100 lb., 10 lb., 5 lb. (2 lots), 2 lb. (2 lots).

It was found that there was little difference between the results for the samples of different weights except in card-room loss and yarn-neppiness. The differences in card-room loss were traced to the fact that whatever may be the weight of the sample a certain amount of cotton (0·1 lb.) is needed to load the card wire; and this amount naturally forms a higher percentage of a smaller sample. The results show that it is possible to deduce correction factors for the card-room losses of samples of small weight that are generally applicable with surprising accuracy. We need only to subtract 1, 2 and 5 from the card-room waste percentage of 10 lb., 5 lb., and 2 lb. sample respectively, to obtain the card-room waste percentage for the cotton when treated in bulk. The yarns from the 2 lb. lots were found to be less neppy than those from the larger lots; this difference was found to be due to the card having been cleaned before the passage of every new lot. The cleaned card is at first able to extract practically all the nep from the cotton which passes through it; the amount of nep appearing in the card web then gradually increases to a maximum, which is reached when about a pound and a half of cotton has passed through. Hence the reduced neppiness of the early portions is only significant when the sample is of such a small weight as 2 lb.

So far as all the other test-results are concerned, the differences between the results for any one count spun from a number of lots of different weight are no more than often obtained for lots of the same weight. For example, a calculation was made of the percentage differences between the results for count-strength products given by bulk and small samples. An analysis of this table gives the following results: of the 40 differences for 5 lb. lots, in 25 cases the 5 lb. lots gave higher values than the bulk, in 15 cases they gave lower values. These results for the 5 lb. lots were distributed as follows:—

Differences between results for 5 lb. lots and bulk	No. of results greater for 5 lb. lots than for bulk.	No. of results less for 5 lb. lots than for bulk.
Less than 2 per cent.	5	4
From 2 to 5 per cent.	11	9
From 5 to 10 per cent.	6	2
Above 10 per cent.	3	0

Of the 40 differences for the 2 lb. lots—in 30 cases the 2 lb. lots gave higher values than the bulk, and in 9 cases they gave lower values ; there was one case in which the values were the same. These results for the 2 lb. lots were distributed as follows :—

Differences between results for 2 lb. lots and bulk	No. of results greater for 2 lb. lots than for bulk.	No. of results less for 2 lb. lost than for bulk.
Less than 2 per cent.	4	2
From 2 to 5 per cent.	8	3
From 5 to 10 per cent.	8	2
From 10 to 15 per cent.	8	2
Above 15 per cent.	2	0

These differences between the results for the samples of different weights may be compared with the differences which are commonly obtaineds in making duplicate tests on the same sample of cotton. As previously pointed out, the average difference between the count-strength products of duplicates was found to be 5·1 per cent. Now if we take all the 5 lb. lots together and all the 2 lb. lots together, we find that on the average their count-strength products are higher than that of the bulk by 1·8 per cent. and 4·3 per cent. respectively. It follows therefore that on the average the difference between the results obtained for the samples of small weights is no more than the difference which is commonly obtained between the duplicates ; for the 5 lb. samples it is decidedly less. Hence it is concluded that although small lots tend to yield slightly higher strength results, yet the difference, for 5 lb. lots at any rate, is negligible.

It might have been expected that the use of small lots would lead to lower instead of higher strength results owing to the difficulties of manipulation, particularly in making a uniform lap with a small sample. The results which have been obtained at the Technological Laboratory show that these difficulties have been successfully overcome. On the other hand, it has to be remembered that there is greater waste made with these small samples ; the card loss is decidedly higher, and, as already remarked, the cleaning power of the card is relatively much greater according as the sample is smaller. It is quite likely therefore that the card removes more short fibres in the case of smaller samples, and that it is on this account that the smaller samples give a rather higher strength. The chief point to observe, how-

ever, is that the difference in strength is really negligible compared with the other unavoidable errors of a spinning test; and if the spinning tests had been confined to tests in duplicate on lots weighing only five pounds or ten pounds respectively, they would have led to accurate conclusions regarding the spinning capacity of the cotton. It is therefore concluded that the procedure which has been adopted in the Technological Laboratory for testing small samples submitted by cotton breeders, *viz.*, making spinning tests in duplicate on lots weighing only 5 lb. each, is completely justified; certainly, there are now the strongest grounds for this conclusion so far as it applies to the range of counts possible with Indian cottons.

VI. Seasonal Variation of the Standard Indian Cottons.*

Few facts are more indisputable than that deterioration of well-known commercial varieties of cotton has often set in after a number of years. But while the fact is indisputable, the explanation of it has been a matter of some controversy. There are those who think that deterioration of any and every variety is bound to occur at some time or other, and that there exists a definite term for any variety beyond which its quality is certain to fall off. On the other hand, the modern scientific view is that the so-called deterioration that has occurred in the past has really been due to contamination of the variety by natural crossing in the field with other and inferior varieties. But quite apart from any long-period deterioration of this kind that may be due to the factors of inheritance, there is the deterioration of quality that may be caused in any one season by an unfavourable environment. This is a matter of great economic importance, because different varieties of cotton do not react in the same way to adverse conditions, and, other things being equal, it is evident that that variety is to be preferred which suffers least under such adverse conditions as may be experienced in a locality generally suitable for it.

The standard Indian cottons are mostly supplied by the Agricultural Departments, and so knowledge is available both of the origin of the seed and of the conditions under which the cottons are grown; it is consequently expected that the repeated annual testing of the standard cottons will throw some light on the question of deterioration. Already a number of the cottons have been tested for four seasons, and most of the others for three seasons. Two properties have been chosen for the investigation of the seasonal variation in these cottons; the first is the fibre-length, and the second is that property of the cotton which sums up all the fibre properties that matter, *viz.*, the highest counts of warp yarn for which the cotton is suitable. The variations in these properties are shown in the following tables:

*"Technological Reports on Standard Indian Cottons, 1927," Indian Central Cotton Committee Technological Laboratory, Bulletin No. 11, Technological Series No. 6, November 1927.

Seasonal variation in Fibre-Length.

Cotton	Province or State	Mean Fibre-length (inch)			
		1923-24	1924-25	1925-26	1926-27
I. Fibre-length variation less than 5 per cent.					
Dharwar 1	Bombay	0·88	0·89	0·89	0·88
Wagad 4	Do.	..	..	0·82	0·86
Wagad 8	Do.	.	..	0·80	0·80
4F	Punjab	..	0·81	0·81	0·79
289F	Do	..	1·01	1·00	0·96
Mollisoni	Do.	..	..	0·72	0·68
J. N. 1	United Provinces	..	0·78	0·77	0·78
C. A. 9	Do.	..	0·89	0·87	0·87
Karunganni C7	Madras	..	0·85	0·83	0·85
Umri Bani	Hyderabad	..	0·85	0·83	0·81
II. Fibre-length variation 5-15 per cent.					
Gadag 1	Bombay	0·90	0·82	0·83	0·81
Surat 1027 A. L. F.	Do.	1·00	0·95	0·92	0·97
A. 19	United Provinces	..	0·71	0·72	0·66
K. 22	Do.	..	0·80	0·80	0·73
Nandyal 14	Madras	0·90	0·89	0·90	0·94
III. Fibre-length variation 15-25 per cent.					
285F.	Punjab	1·04	0·92	0·94	0·83
Co. 1	Madras	1·04	0·86	0·90	0·93
Hagari 25	Do.	0·90	0·86	0·85	0·77

Seasonal variation in highest suitable counts.

Cotton	Province or State	Highest Suitable Counts			
		1923-24	1924-25	1925-26	1926-27
Highest count-variation less than 10 per cent.					
Dharwar 1	Bombay	34	34	34	34
4F.	Punjab	..	22	22	24
K. 22	United Provinces	..	12	12	12
Nandyal 14	Madras	34	32	32	34
Karunganni C7	Do.	..	26	26	26
Umri Bani	Hyderabad	..	22	24	24
II Highest count—variation 10-20 Per cent.					
Surat 1027 A. L. F.	Bombay	30	32	26	32
Wagad 4	Do.	..	..	14	16
Wagad 8	Do.	..	..	12	14
285F.	Punjab	34	34	28	34
A. 19	United Provinces	..	6/8	8	6/8
J. N. 1	Do.	..	12	12	14
C. A. 9	Do.	..	28	28	34
Hagari 25	Madras	24	28	26	26
III. Highest count—variation above 20 per cent.					
Gadag 1	Bombay	36	20	30	38
289F.	Punjab	..	36	30	38
Mollisoni	Do.	..	..	6	8
Co. 1	Madras	32	30	32	38

It will be seen that three cottons (Punjab-American 285F, Coimbatore 1 and Hagari 25) show a maximum seasonal variation of between 15 and 25 per cent. in fibre-length and four cottons (Gadag 1, Punjab-American 289F, Mollisoni, and

Coimbatore 1) show a maximum seasonal variation of more than 20 per cent. in highest suitable counts.

From the results at present available it is deduced that there is no evidence to show that any of the standard cottons has undergone deterioration of type within the period concerned. If the deterioration had been one of type, a more or less progressive falling off in the highest suitable counts might have been expected to occur, but no such falling off can, in fact, be discerned. It may be, of course, that it would take more than four seasons to detect any deterioration of this kind owing to the predominating effect of seasonal variation due to other causes; conclusions on this point can in the nature of the case only be arrived at after the expiry of a number of further seasons. It may be mentioned that the variation which has occurred is ascribed to climatic and other differences; this is strikingly borne out by the fact that the seasonal variation is widely distributed, occurring in cottons grown in a number of the different provinces. There is no doubt that as the years pass, and these and other tests are repeated, the information obtained will become more and more valuable.

VII. Fibre Properties and Spinning Value.*

Reference has already been made (Part I) to the desirability of determining the quality of a cotton in terms of fibre-properties. It is hoped that the extended examination of the fibre-characters of the standard Indian cottons will provide the basis of a really scientific attempt to evacuate just those properties which matter. A beginning has already been made, and the results now published embrace a sufficient number of properties to make the comparisons really interesting. Investigations have been made on the following fibre-properties:

(1) Mean fibre-length;
(2) Fibre-length distribution;
(3) Mean fibre-strength;
(4) Mean fibre-weight per inch;
(5) Mean fibre-rigidity;
(6) Mean ribbon-width;
(7) Mean number of convolutions per inch.

The manner in which these properties have been measured is as follows:—

Fibre-length and Fibre-length Distribution. In the determination of fibre-length it has to be remembered that a sample of even a pure strain cotton contains fibres of many different lengths. The mean fibre-length is determined by means of two different instruments, *viz.*, (1) the Balls Sorter; and (2) the Baer Sorter; the results from these two instruments serve as checks upon each other. Four

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*"Technological Reports on Standard Indian Cottons, 1927," Indian Central Cotton Committee Technological Laboratory, Bulletin No. 11, Technological Series No. 6, November 1927.

determinations are made with the Balls Sorter and eight with the Baer Sorter. The tests on the Balls Sorter also serve to show the fibre-length distribution, which indeed has to be determined before the mean fibre-length can be ascertained.

Fibre-strength. The mean fibre-strength is determined by two methods, *viz.*, (1) the Balls Magazine Hair Tester; and (2) the O'Neill Tester, as modified by Mann and Peirce.* 300 fibres are tested for strength by each method.

Fibre-weight. The mean fibre-weight is determined by cutting a straightened bunch of fibres so as to yield a number of lengths each one centimetre long; 10 groups each containing 400 of these 1 cm. lengths are then weighed separately on a quartz-fibre torsion micro-balance and the mean fibre-weight unit per length calculated from the results.

Fibre-rigidity. The mean fibre-rigidity at 70 per cent. relative humidity is determined by measuring the time of torsional vibration of a small cylindrical aluminium rod suspended horizontally at its mid-point by the cotton fibre under test; each aluminium rod is half an inch long and weighs 0·0178 gramme (0·00063 oz.). The fibre-rigidity is determined for 150 individual fibres of each sample.

Ribbon-width. The mean ribbon-width of the 1923-26 cottons was obtained from measurements under the microscope of 50 different fibres. Each measurement was taken midway between a pair of convolutions, as it is at this point only that the full ribbon-width is seen under the microscope; 10 observations were made on each fibre, and the mean taken of the whole 500 observations. For the determination of the ribbon-width of the 1926-27 cottons, measurements were made on 150 different fibres, involving 1,500 observations.

Convolutions. The number of convolutions or natural twists in the cotton fibre was also obtained from measurements under the microscope, the total number of convolutions being determined for each of 50 fibres, and the mean taken; in the case of the 1926-27 cottons measurements were made on 150 fibres. In these reports a convolution is regarded as being due to the twisting of the fibre on its longitudinal axis through an angle of 180 degrees.

The properties of fibre-strength, fibre-weight, and fibre-rigidity were determined for the 1926-27 cottons only. For the measurement of the fibre properties the present routine is to make successive tests on the same 150 fibres for the number of convolutions, ribbon-width, and fibre-rigidity. It should be noted that this number of observations is really very few for the determinations of the fibre-rigidity and of the number of convolutions, both of which have a large probable error of a single observation; for this reason the mean values obtained for these characters must be regarded as only approximate, and as liable to a considerable sampling error.

Comparisons have been made between the several fibre-properties and the highest suitable warp counts for which each cotton is suitable as shown in the table below:

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* *Journal of the Textile Institute,* XVII, 1926, page T. 84.

Fibre properties of standard Indian cottons, 1926-27.

1	2	3	4	5	6	7	8	9
Cotton	Highest standard warp counts	Fibre-length (inch)	Fibre-strength (oz.)	Fibre-weight per inch (10^{-7}oz.)	FIBRE-STRENGTH / Fibre-weight per inch (10^{-6}oz.)	Ribbon-width (10^{-3} in.)	Convolutions per inch	Fibre-Rigidity (oz.-in. $^2 \times 10^{-7}$)
Memphis (American), 1925-26	40	0·95	0·156	1·78	0·88	0·62	110	1·46
Punjab-American 289F	38	0·97	0·111	0·98	1·13	0·62	88	0·53
Coimbatore 1	38	0·92	0·130	1·56	0·83	0·59	91	1·24
Gadag 1 (Dharwar-American)	38	0·81	0·142	1·77	0·80	0·63	110	1·51
Dharwar 1	34	0·89	0·172	2·04	0·84	0·61	67	1·09
Punjab-American 285F	34	0·82	0·117	1·04	1·13	0·64	100	0·59
Cawnpore-American C. A. 9	34	0·87	0·164	1·82	0·90	0·61	119	1·85
Nandyal 14	34	0·93	0·228	1·90	1·20	0·61	46	1·42
Surat 1027 A. L. F.	32	0·97	0·168	2·01	0·84	0·73	96	1·62
Texas (American), 1925-26	30	0·86	0·166	2·04	0·81	0·58	140	2·10
Hagari 25	26	0·76	0·112	1·76	0·64	0·65	54	0·97
Karunganni	24	0·85	0·188	1·92	0·98	0·65	57	1·70
Punjab-American 4F	24	0·78	0·134	1·34	1·00	0·70	104	0·93
Umri Bani	24	0·81	0·187	1·99	0·94	0·67	65	1·60
Wagad 4	16	0·85	0·184	2·54	0·73	0·68	46	1·89
Wagad 8	14	0·80	0·183	2·60	0·69	0·72	45	2·21
Bundelkhand J. N. 1	14	0·77	0·187	2·42	0·77	0·71	65	2·16
Cawnpore K. 22	12	0·73	0·182	2·37	0·78	0·71	72	2·80
Mollisoni	8	0·68	0·168	2·69	0·62	0·77	65	2·42
Aligarh A. 19	6/8	0·66	0·192	3·00	0·64	0·79	80	3·61

It is found that when the different cottons are arranged in order of increasing coarseness of highest suitable counts, there is a general trend in the values of any given fibre-property similar to that of the counts, but in all cases there are outstanding exceptions. The parallelism is most marked in the cases of fibre-length and ribbon-width, and less so in fibre-strength fibre-weight, number of convolutions and fibre-rigidity. However, there are so many individual exceptions to each general trend that it is concluded that no single fibre property can serve as a universal criterion to indicate the highest suitable counts into which a cotton can be spun. It is evident that a number of properties must be taken into consideration, and that the culmination of this work, leading to the assigning of a definite numerical fraction to the part taken by each fibre-character, will be a matter of some years' further investigation.

A PRELIMINARY REPORT ON EXPERIMENTS IN THE CONTROL OF GRAIN SMUT OF JOWAR (*ANDROPOGON SORGHUM*).

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AMONG the cultivated crops in the Bombay Presidency, *Andropogon Sorghum*, locally known as *jowar*, occupies the first place as regards acreage, covering an area of over eight million acres. The most important disease attacking this crop is the grain smut caused by *Sphacelotheca sorghi* (Link) Clinton. The value of the grain destroyed by this disease in the Bombay Presidency alone exceeds two crores of rupees annually. The seed treatment in use in the Bombay and Madras Presidencies is the copper sulphate treatment which requires steeping the grains for 10 to 15 minutes in a two-per cent. solution of copper sulphate. This treatment, though effective, is not entirely satisfactory, as it wets the grains and necessitates drying before they can be sown. Moreover, in 1926 it was pointed out by Mr. T. F. Main, now Director of Agriculture, Bombay Presidency, that "copper sulphate propaganda in areas lightly affected by smut tends to defeat its own ends by being irksome to cultivators", with the result that they will sow smutted seed rather than steep it in a copper sulphate solution. It therefore seemed desirable to use some of the dust fungicides and determine their effect on the control of the smut. It was also recognised that cultivators would prefer dry fungicides to liquid preventives because of the difficulties involved in the use of the latter.

The seed was divided into eight lots and was artificially infected, with different quantities of smut spores. The dosage by weight ranged from 1 part of smut spores to 250 parts of seed (1-250) to 1 to 3000 (1-3000). With the heaviest spore load (1-250), the seed was practically blackened and was very much smuttier than the seed with the heaviest natural infection. The lightest spore load (1-3000) gave a few hundred spores per seed, which were barely visible to the naked eye. The

* The writers are grateful to Mr. M. N. Kamat, Assistant Professor of Mycology, College of Agriculture, Poona, for helping in the field work.

heaviest spore loads were used to ascertain the limits of efficiency of the different fungicides.

The fungicides used in these experiments were in the dust or powder form. They were: 1. Copper carbonate (containing 53 per cent. copper). 2. Sulphur No. 1 (passed through 100-mesh sieve). 3. Sulphur No. 2 (passed through 250-mesh sieve). 4. Copper sulphate No. 1 (coarse powder). 5. Copper sulphate No. 2 (passed through 200-mesh sieve).

For each set of experiments controls were run with untreated, infected seed, and in each case fairly heavy infection was secured.

The results of these experiments may be summarised as follows :—

1. Copper carbonate is most effective in controlling smut. Two to four ounces of the dust per sixty pounds of seed controlled infection for all spore loads except the heaviest (1-250), where there was slight infection. Even one ounce of the dust was found to be effective for dosages of 1-1000 or less ; in heavier spore loads infection was very slight, the maximum being three per cent. in the case of the 1-500 spore load.

2. Besides giving a better distribution of the dust on the seed when finer sulphur is used, fineness of the particles does not seem to have any effect in controlling infection. Sulphur applied at the rate of four ounces per sixty pounds of seed was practically fully effective except for the heaviest dosage of smut spores (1-250). Three ounces of sulphur No. 1 practically controlled smut for spore dosages of 1-750 or less, the results with the higher spore loads being more or less erratic. Sulphur No. 2 applied at the same rate was found to be less effective and controlled infection for spore loads of 1-1000 or less. Sulphur No. 1 was unsatisfactory at the rate of one or two ounces, but a satisfactory control was secured with sulphur No. 2 at the rate of two ounces for spore loads of 1-1000 or less.

Considering that four ounces of sulphur per sixty pounds of seed are required for the best results in smut control, it will cost less than one pie to treat enough grain to sow one acre.

3. Copper sulphate No. 1 failed to control infection for any dosage of spores even when applied at the rate of four ounces per sixty pounds of seed. However, copper sulphate No. 2 was very promising. Two to four ounces of this dust was practically fully effective, except for the heaviest dosage of spores (1-250), where the maximum infection was six per cent. One ounce of copper sulphate No. 2 was also effective for spore loads of 1-1500 or less.

The results of these experiments show that the present system of soaking in preparing jowar seed for sowing, as a preventive of grain smut, can be replaced by a dust system. Sulphur, however, shows great promise as it is equal to copper sulphate steeping in effectiveness, and is easier to apply and much cheaper than the latter or any of the dust fungicides used.

SOME OBSERVATIONS ON THE EFFECT OF THE HIGH CONCENTRATION OF ORGANIC OR AMMONIACAL NITROGEN ON NITRIFICATION IN SOIL.*

BY

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In order to find out the optimum quantity of organic material to be used for nitrification experiments, experiments were conducted with different amounts of oilcake and, side by side, similar amounts of nitrogen were used in the form of ammonium sulphate, and it was found that beyond 90 mgms. of nitrogen per 100 gms. of soil and quantities higher than that did not show any accumulation of nitrates but only large quantities of ammoniacal nitrogen were found to be present and sometimes nitrite nitrogen also. After some time ammoniacal nitrogen as well as nitrite nitrogen tended to disappear altogether from the soil. The soil used for the experiments was taken from fields recently brought under cultivation.

The causes assigned for these changes were such as fitted in with the knowledge of the physiological activity of the nitrifying organisms (as ascertained by the early workers in this field), *viz.*, the presence of large amounts of organic matter[1] which is considered detrimental to nitrifying organisms and (2) the presence of large amounts of ammoniacal nitrogen [2] (generated as a result of chemical and biological changes) which is supposed to inhibit nitrification. It has been, however, found by later workers[3] that nitrifying organisms can tolerate much larger amounts of organic matter and ammoniacal nitrogen than those given by the early investigators.

In our experiments further on with other soils, *e.g.*, rich garden soil, soil near the manure pits, etc., it was found that up to 90 mgms. of organic nitrogen per 100 gms. soil could be nitrified without any accumulation of large amounts of ammoniacal nitrogen. Hence it is open to doubt whether the causes given are sufficient to explain away the non-appearance of the nitrification activity when large amounts of organic manures or ammoniacal salts are added to the soil.

In order to find the reasons for this, therefore, an experiment was started on new lines. The soil from the field was incubated with the optimum quantity of oil-cake or ammonium sulphate, as the case may be, for about six weeks and then

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* Paper read before the Agricultural Section of the fifteenth session of the Indian Science Congress held at Calcutta in January 1928.

[1] Winogradsky, S. 1890, 1891. Recherches sur les organisms de la nitrification. *Ann. Inst. Pasteur*, p. 4, pp. 213-357, 760-771.

[2] Boullangar and Masol. Etudes sur les Microbes Nitrifications. *Ann. Inst. Past.* p. 17, pp. 492-520.

[3] Fred, E. B. and Davenport, A. Organic compounds and Nitrification. *Soil Sc.* Vol. XI, p. 389 (1921).

Joshi, N. V. Intensive Nitrifying, etc. *Agric. Jour. India*, Vol. XX, pp. 20-36, 1925.

washed free of its nitrates, and this washed soil was tested for its capacity to nitrify cake and ammonium sulphate as the case may be, and it was found that this washed soil could nitrify large quantities of organic nitrogen (120 mgms. per 100 gms. soil) without the accumulation of ammoniacal nitrogen, showing that the soil treated in this way is, so to say, activated in such a way as to be able to nitrify large quantities of organic or ammoniacal nitrogen.

This result we are inclined to attribute to the large increase in the soil of the numbers of nitrifying organisms which are able to deal with large quantities of ammoniacal nitrogen as it begins to form either from cake or by the interaction of ammonium sulphate and calcium carbonate. Also, side by side, the proportionate decrease in other organisms or the ratio between nitrifiers and non-nitrifiers is altered in such a way as to favour the nitrification process.

As already pointed out above, Fred and Davenport who carried on investigation on the physiological activity of the nitrifying organisms have observed that the nitrifying organisms can grow in the presence of large quantities of organic matter. In our study on the process of intensive nitrification of urine,[1] it was observed by us that nitrite and nitrate forming organisms could grow on ordinary agar along with other organisms. These impure cultures growing on ordinary agar (with Lemco and peptone) when inoculated into Omelianski and nitrite solution were able to form nitrites and nitrates. These impure cultures showed two or three kinds of organism, when examined under the microscope. Later some strains, which (so far as microscopic examination and cultural appearance could show) may be considered pure cultures, were isolated and these could be grown on ordinary agar for one transfer (two or three days) only and these when inoculated into Omelianski and nitrite solutions could show nitrites and nitrate formation, as the case may be, but after growing for this short time, loss of nitrifying power occurred. This loss of nitrifying power could sometimes be recovered by re-inoculation into Omelianski solution and nitrite culture solutions.

Unfortunately, these organisms could not be grown continuously for a longer period on ordinary agar.

In any case these strains were of a kind suitable for our purpose of inoculation in a new experiment. In this experiment an attempt was made to find out whether it is the nitrite or nitrate formers which influence the course of nitrification, whether it is the strain of nitrifying organisms or the numbers which affect the rapid nitrification and tolerance of high content of NH_3 noticed in the process of intensive nitrification.

From the tables attached, it may be seen that it is the nitrate forming organisms and their number contained in the inoculum that cause increased nitrification and tolerance of NH_3 in the case of cake or ammonium sulphate.

It appears that nitrite forming organisms are not of any great help probably because they are already present in sufficiently large numbers. One other reason

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[1] Joshi, N. V. Intensive Nitrifying, etc. *Agric. Jour. India*, Vol. XX, pp. 20-36, 1925.

why the nitrite forming organisms are not of any great help in the nitrification process appears to be that the nitrates are probably the most stable product of this process and that the intermediate products that are formed, *viz.*, ammoniacal salt and nitrites are compounds which are unstable in the soil and are decomposed if not rapidly converted into nitrates.

As a test of this hypothesis, an experiment was conducted with 120 mgms. of nitrogen in the form of oil cake, ammonium sulphate, sodium nitrite and potassium nitrate added to the soil, it was found that nitrite nitrogen disappears most in a short time. Next in order comes ammonical nitrogen. It might be that the nitrogen is converted into organic nitrogen or it might have escaped as free nitrogen. This requires further trials. It is also necessary to work with smaller amounts of nitrite and ammoniacal nitrogen.

In any case it is more or less established that large quantities of nitrite nitrogen and ammoniacal nitrogen, if present in the soil, will be wasted unless converted into nitrates by the nitrate forming organisms.

In order to see whether the supposition that the nitrate forming organisms have multiplied in large numbers in our experiments cited above is correct, it was proposed to observe the correlation between the amount of nitrates formed and the number of organisms observed in the soil by the direct counts under the microscope. The tables are attached. Owing to these counts including all kinds of bacteria, it is not quite clear whether there is any correlation, but it can be said that, wherever the nitrification is going on, the number of organisms is maintained at a higher level for a longer period than in those cases where nitrification does not proceed.

TABLE 1.

Soil + 16 % Moisture=Control.
Soil + 16 % Moisture + 0·5 % Extracted Oil-cake.
Soil + 16 % Moisture + 1 % Extracted Oil-cake.
Soil + 16 % Moisture + 1·5 % Extracted Oil-cake.
Soil + 16 % Moisture + 2 % Extracted Oil-cake.
Soil + 16 % Moisture + 3 % Extracted Oil-cake.

Treatment.		MGMS. NITROGEN AS AMMONIA, NITRITES AND NITRATES					
		1st week	2nd week	3rd week	4th week	6th week	8th week
1. Control	N. as NH_3	2·52	8·4	2·52	7·56	15·96	3·36
	NO_2	0·8748	Trace	Trace	Trace	Trace	Trace
	NO_3	2·7	2·4	4·8	6·0	4·8	6·0
2. Control + 0·5% cake	NH_3	18·48	7·56	5·88	14·28	10·92	5·04
	NO_2	0·972	3·11	0·1555	Trace	0·0583	Trace
	NO_3	1·2	4·2	15·6	24·0	24·0	24·0

TABLE I—*contd.*

Treatment.	N. as	Mgms. nitrogen as ammonia, nitrites and nitrates					
		1st week	2nd week	3rd week	4th week	6th week	8th week
3. Control + 1% cake.	NH_3	22·68	14·28	10·08	15·96	6·72	8·4
	NO_2	0·3888	2·332	1·5552	3·110	2·332	Trace
	NO_3	0·9	2·1	3·6	Trace	24·0	37·5
4. Control + 1·5 % cake	NH_3	31·08	24·36	23·52	16·8	9·24	10·92
	NO_2	0·2916	3·110	1·944	3·11	0·7776	Trace
	NO_3	Trace	Trace	2·7	Trace	3·2	6·8
5. Control + 2 % cake.	NH_3	47·88	69·72	76·44	67·2	56·28	98·28
	NO_2	0·03888	0·3110	0·7775	0·7775	0·1944	0·7776
	NO_3	Trace	*Nil*	*Nil*	Trace	Trace	Trace
6. Control + 3 % cake.	NH_3	67·2	73·92	107·52	88·2	71·40	111·72
	NO_2	Trace	*Nil*	0·1166	0·0972	Trace	Trace
	NO_3	Trace	*Nil*	*Nil*	Trace	Trace	Trace

TABLE II.

1. Soil + 16 % Moisture + 30 mgms. N. (per 100 gms. soil) as $(NH_4)_2SO_4$.
2. Soil + 16 % Moisture + 90 mgms. N. (per 100 gms. soil) as $(NH_4)_2SO_4$.
3. Soil + 16 % Moisture + 120 mgms. N. (per 100 gms. soil) as $(NH_4)_2SO_4$.
4. Soil + 16 % Moisture + 200 mgms. N. (per 100 gms. soil) as $(NH_4)_2SO_4$.
5. Soil + 16 % Moisture + 300 mgms. N. (per 100 gms. soil) as $(NH_4)_2SO_4$.

Treatment.	N. as	Mgms. nitrogen as ammonia, nitrites and nitrates per 100 gms. soil					
		1st week	2nd week	3rd week	4th week	6th week	8th week
1. Soil + 16 % Moisture + 30 mgms. N. as $(NH_4)_2SO_4$.	NH_3	24·36	20·86	15·12	12·48	11·62	8·4
	NO_2	0·3888	2·5264	3·888	3·888	0·972	0·0777
	NO_3	2·4	3·0	3·0	9·6	18·0	24·0
2. Soil + 16 %Moisture + 90 mgms. N. as $(NH_4)_2SO_4$	NH_3	67·20	61·32	56·24	47·88	10·08	12·48
	NO_2	Trace	0·5832	1·166	3·888	2·332	3·498
	NO_3	1·2	1·8	2·4	3·6	6.0	7·2
3. Soil + 16% Moisture + 120 mgms. N. as $(NH_4)_2SO_4$.	NH_3	88·34	82·18	77·38	68·74	33·32	31·08
	NO_2	Trace	0·07776	Trace	4·859	3·498	3·888
	NO_3	1·2	1·2	1·8	1·8	2·1	2·4
4. Soil + 16% Moisture + 200 mgms. N. as $(NH_4)_2SO_4$.	NH_3	131·04	126·0	110·88	110·88	63·84	34·44
	NO_2	Trace	0·07776	Trace	5·832	0·972	4·860
	NO_3	1·2	0·9	Trace	2·1	1·2	2·7
5. Soil = 16% Moisture + 300 mgms. N. as $(NH_4)_2SO_4$.	NH_3	189·84	183·96	117·36	142·8	78·2	33·6
	NO_2	Trace	0·07776	Trace	0·1944	0·0972	4·860
	NO_3	1·2	0·9	Trace	2·1	1·2	2·7

TABLE III.

Nitrification experiment with oil-cake and ammonium sulphate at 30 mgms. nitrogen and 120 mgms. nitrogen per 100 gms. soil.

Treatment.		Mgms. nitrogen as ammonia nitrites and nitrates			
		1st week	2nd week	3rd week	4th week
	N. as				
Soil + Extracted Sarso cake @ 30 mgms. N. per 100 gms. soil.	NH_3	16·8	7·98	8·4	6·72
	NO_2	1·0886	6·9984	0·5832	0·03888
	NO_3	1·2	4·8	18·0	18·0
Soil + Extracted Sarso cake @ 120 mgms. N. per 100 gms. soil.	NH_3	47·54	42·12	42·84	27·3
	NO_2	*Nil*	0·03888	*Nil*	*Nil*
	NO_3	1·2	*Nil.*	Trace	0·9
Soil + Am_2SO_4 @ 30 mgms. Nitrogen per 100 gms. soil	NH_3	25·2	7·56	5·46	3·74
	NO_2	2·916	5·832	2·916	0·01944
	NO_3	Trace	4·8	12·0	31·2
Soil + Am_2 SO_4 @ 120 mgms. Nitrogen per 100 gms. soil	NH_3	91·98	83·56	68·88	34·86
	NO_2	0·02916	0·0486	0·0777	0·0388
	NO_3	Trace	Trace	0·9	0·9
Nitrification experiment with the soil in which nitrification had gone on for 4 weeks.					
Soil previously nitrified and containing 18 mgms. Nitrate Nitrogen initially + 120 mgms. Nitrogen per 100 gms. soil in the form of oil-cake.	NH_3	73·36	..	..	10·92
	NO_2	2·3328	0·3888	..	0·03888
	NO_3	21·6	43·2	..	72·0
Soil previously nitrified and washed out and containing no nitrate nitrogen initially + 120 mgms. Nitrogen per 100 gms. soil in the form of oil-cake.	NH_3	73·92	..	..	9·24
	NO_2	2·916	0·3499	..	0·0582
	NO_3	6·0	62·4	..	78·0

TABLE IV.

Nitrification experiment.

Treatment		Mgms. nitrogen as ammonia nitrites and nitrates			
		1st week	2nd week	3rd week	4th week
	N. as				
1. Soil + 16% Moisture (Control)	NH_3	2·10	3·78	..	..
	NO_2	Trace	Trace	0·1944	*Nil*
	NO_3	3·3	3·6	4·5	5·4
2. Control + Cake @ 90 mgms. Nitrogen per 100 gms soil.	NH_3	45·36	27·4	..	10·92
	NO_2	0·6998	2·916	4·665	4·66
	NO_3	Trace	2·4	3·6	7·2

TABLE IV—*contd.*

Nitrification experiment.

Treatment	N. as	Mgms. nitrogen as ammonia nitrites and nitrates: 1st week	2nd week	3rd week	4th week
3. Same as Number 2 + 1 c.c. culture of nitrate formers autoclaved.	NH_3	46·2	42·42	..	15·96
	NO_2	0·388	2·022	3·888	2·333
	NO_3	Trace	1·2	2·1	2·4
4. Same as Number 2 + 10 c.c. culture of nitrate formers autoclaved.	NH_3	49·98	43·68	..	14·7
	NO_2	0·3888	2·498	3·888	4·667
	NO_3	3·0	3·6	5·4	5·4
5. Same as Number 2 with 1 c.c. culture of nitrate formers.	NH_3	50·4	44·94	..	20·16
	NO_2	0·3888	0·3888	3·11	3·888
	NO_3	Trace	1·2	2·1	3·0
6. Same as Number 2 with 10 c.c. culture of nitrate formers.	NH_3	40·74	43·26	..	11·34
	NO_2	0·3888	1·944	0·311	0·1944
	NO_3	3·3	6·0	36·0	52·8
7. Same as Number 2 + 1 c.c. culture of nitrite formers autoclaved.	NH_3	44·10	43·68	..	10·08
	NO_2	0·3888	1·555	3·11	1·944
	NO_3	*Nil*	0·9	3·0	5·4
8. Same as Number 2 + 10 c.c culture of nitrite formers autoclaved.	NH_3	43·36	42·84	..	14·28
	NO_2	0·3888	1·3996	3·5092	1·944
	NO_3	*Nil*	0·9	3·0	5·4
9. Same as Number 2 + 1 c.c. culture of nitrite formers.	NH_3	42·42	44·10	..	17·64
	NO_2	3·888	1·552	2·916	2·333
	NO_3	*Nil*	0·9	3·0	5·4
10. Same as Number 2 + 10 c.c. culture of nitrite formers.	NH_3	44·94	42·0	..	14·70
	NO_2	0·3888	1·1664	3·888	3·11
	NO_3	*Nil*	0·9	3·0	5·4

TABLE V.

Soil + 16 % Moisture=Control.

Soil + 16 % Moisture +Extracted Sarso Cake @ 120 mgms. N.

Soil + Am_2 SO_4 @ 120 mgms. N per 100 gms. soil + 16 % Moisture.

Soil + $NaNO_2$ @ 120 mgms. N per 100 gms. soil + 16 % Moisture.

Soil + $NaNO_3$ @ 120 mgms. N per 100 gms. soil + 16 % Moisture.

Treatment	N. as	Mgms. nitrogen as NH_3, NO_2, and NO_3: 1st week	2nd week	3rd week	4th week	6th week	8th week
Control . . .	NH_3	4·20	1·68	1·68	2·32	2·52	6·72
	NO_2	0·3888	*Nil*	*Nil*	*Nil*	*Nil*	*Nil*
	NO_3	*Nil*	3·75	Trace	4·5	4·5	3·6
Control + Cake @ 120 mgms. N. per 100 gms. soil.	NH_3	36·96	51·24	46·2	42·0	25·2	18·48
	NO_2	Traces	*Nil*	*Nil*	1·1664	7·29	2·916
	NO_3	*Nil*	*Nil*	*Nil*	3·0	3·0	3·0
Control + $(NH_4)_2$ SO_4 @ 120 mgms. N. per 100 gms. soil.	NH_3	100·8	90·72	78·12	25·2	19·32	22·68
	NO_2	Trace	*Nil*	0·3888	5·832	7·29	1·944
	NO_3	*Nil*	*Nil*	Traces	6·0	6·0	7·5

TABLE V—*contd.*

Treatment		Mgms. nitrogen as NH_3, NO_2, and NO_3.					
		1st week	2nd week	3rd week	4th week	6th week	8th week
	N. as						
Control + $NaNO_2$ @ 120 mgms. N. per 100 gms. soil.	NH_3	8·4	5·04	10·92	4·2	6·72	7·56
	NO_2	8·748	2·432	4·864	4·864	3·8888	1·944
	NO_3	9·0	9·0	12·0	9·0	12·0	6·0
Control + $NaNO_3$ @ 120 mgms. Nitrogen per 100 gms. soil.	NH_3	5·04	6·72	6·72	5·88	3·36	2·52
	NO_2	0·7776	0·5832	0·972	1·215	3·888	0·1944
	NO_3	120·0	120·0	90·0	97·5	90·0	96·0

TABLE VI.

Treatment		Mgs. nitrogen per 100 gms. soil				
		1st week	2nd week	4th week	6th week	8th week
	N. as					
1. Soil + 16 % Water . .	NH_3	5·88	3·36	5·04	3·36	4·20
	NO_2	0·3888	Trace	Trace	Trace	Trace
	NO_3	1·8	3·6	4·8	3·6	6·0
2. Soil + Cake @ 120 mgms. Nitrogen + Water 16 %.	NH_3	47·88	50·4	40·32	21·84	20·16
	NO_2	0·0583	Trace	0·972	1·944	1·944
	NO_3	*Nil*	Trace	1·5	3·0	4·8
3. Soil + Am_2SO_4 @ 120 mgms. Nitrogen + Water 16 %.	NH_3	105·84	91·56	75·6	42·0	6·72
	NO_2	0·0777	0·1166	0·972	3·010	0·1944
	NO_3	Trace	Trace	1·5	3·0	7·8
4. Soil + Inoculum of Nitrifying culture 10 cc. + Water to make up 16%.	NH_3	46·2	9·24	5·88	5·88	3·36
	NO_2	0·1166	0·1166	0·1166	0·486	Trace
	NO_3	7·8	6·0	12·0	12·0	12·0
5. Soil + Inoculum of Nitrifying culture 10 cc. + Water to make up 16 % + Cake @ 120 mgms. Nitrogen.	NH_3	68·88	63·84	36·96	31·92	22·68
	NO_2	0·777	0·1555	0·166	4·276	4·86
	NO_3	2·7	6·0	7·2	24·0	52·8
6. Soil + Inoculum of Nitrifying culture 10 cc. + Water to make up 16 % + $(NH_4)_2SO_4$ @ 120 mgms. Nitrogen.	NH_3	109·2	99·96	60·48	9·24	3·36
	NO_2	0·3888	1·2437	1·944	0·486	0·1944
	NO_3	7·8	6·0	1·32	69·0	78·0

Number of organisms in millions per gram. of soil

1.	5·0	5·2	4·2	3·64	2·2
2.	6·4	4·7	4·5	6·0	3·84
3.	3·4	5·8	2·3	2·72	3·76
4.	9·3	2·8	2·6	3·5	2·1
5.	8·9	7·2	5·7	5·8	3·3
6.	7·2	8·8	7·64	7·7	2·5

Table VII.

Treatment	N. as	Mgms. nitrogen as ammonia, nitrites and nitrates: 1st week	2nd week	4th week	6th week	8th week
1. Soil + 16 % H_2O + $(NH_4)_2SO_4$ @ 30 mgms. Nitrogen.	NH_3	45·36	4·20	5·88	6·72	5·04
	NO_2	1·5552	2·721	1·944	0·1555	Trace
	NO_3	1·5	4·8	18·0	24·0	43·2
2. Soil + 16 % H_2O + Cake @ 30 mgms. Nitrogen.	NH_3	14·28	40·32	6·72	8·40	9·24
	NO_2	0·486	4·0824	0·3110	0·0777	Trace.
	NO_3	1·8	6·0	22·5	24·0	32·8
3. Soil + 40 c.c. inoculum of Nitrifying organisms + Water to make up to 16% + $(NH_4)_2SO_4$ @ 120 mgms. Nitrogen per 100 gms. soil.	NH_3	98·28	33·6	60·48	9·24	7·56
	NO_2	0·3888	0·5832	0·777	0·03888	Trace
	NO_3	24·0	19·2	36·0	36·0	78·0
4. Soil + 40 c.c. inoculum of Nitrifying organisms + Water to make up to 16% + cake @ 120 mgms. Nitrogen per 100 gms. soil.	NH_3	25·2	59·64	58·8	31·92	10·92
	NO_2	0·0777	0·6998	1·555	0·03888	Trace
	NO_3	21·6	24·0	19·5	66·0	78·0

Number of organisms in millions per gram. of soil.

	1st week	2nd week	4th week	6th week	8th week
1.	0·9	1·55	4·4	3·68	2·0
2.	0·9	2·2	7·8	4·08	3·2
3.	3·6	5·4	10·7	10·2	3·0
4.	8·4	11·0	10·4	12·2	3·5

Table VIII.

Treatment	N. as	Mgms. nitrogen as ammonia, nitrites and nitrates: 1st week	2nd week	4th week	6th week	8th week
1. Soil + Inoculum of nitrifying organisms, 10 c.c. + $(NH_4)_2SO_4$ @ 30 mgms. N. per 100 gms. soil + H_2O to make up 16 %.	NH_3	17·64	3·36	5·04	4·20	4·20
	NO_2	1·555	0·3110	0·1166	0·03888	Trace
	NO_3	6·0	21·0	33·6	30·0	30·0
2. Soil + Inoculum of nitrifying organisms, 10 c.c. + Cake @ 30 mgms. N. per 100 gms. soil + H_2O to make up 16 %.	NH_3	5·88	5·04	5·04	5·04	6·72
	NO_2	1·555	0·1166	0·1944	0·03888	0·1944
	NO_3	7·2	24·0	27·0	27·0	21·0

TABLE VIII—*contd*.

Treatment	N. as	1st week	2nd week	4th week	6th week	8th week
		Mgms. nitrogen as ammonia, nitrities and nitrates				
3. Soil + Inoculum of nitrifying Organisms, 40 c.c. + Water to make up to 16%.	NH_3	10·92	3·36	3·36	4·20	3·36
	NO_2	0·1944	0·1555	0·0777	0·03888	Trace.
	NO_3	24·0	22·5	30·0	30·0	24·0
4. Soil + Inoculum of nitrifying organisms, 40 c.c. + Water to make up to 16% + Am_2SO_4 @ 30 mgms. Nitrogen.	NH_3	8·40	3·36	5·88	4·20	6·72
	NO_2	0·311	0 ·1555	0·1944	0·0388	0·1944
	NO_3	28·8	36·0	60·0	43·2	37·5
5. Soil + Inoculum of nitrifying organisms, 40 c.c. + Water to make up to 16 % + Cake @ 30 mgms. Nitrogen.	NH_3	10·08	7·56	4·20	5·04	7·56
	NO_2	0·777	0·3110	0·0777	0·0777	0·1944
	NO_3	21·6	33·6	38·4	45·0	39·0

Number of organisms in millions per gram. of soil.

	1st week	2nd week	4th week	6th week	8th week
1.	2·3	4·5	3·72	6·1	2·5
2.	4·1	5·7	3·5	6·9	2·5
3.	3·0	4·3	3·04	8·0	2·0
4.	3·9	5·2	5·6	10·2	3·5
5.	7·0	4·7	5·4	14·0	4·4

NOTES

LONGEVITY OF SUGARCANE POLLEN.

In the endeavour to combine the desirable qualities of certain varieties of plants, those engaged in hybridization work are often faced with the difficulty that the varieties it is desired to cross with each other, come into bloom at different periods, and sometime the same variety flowers in one locality but fails to do so in another. In sugarcane breeding, for instance, the interval between the arrowing of sugarcane varieties—four weeks or more in certain cases—has always stood in the way of crossing varieties which it would be very desirable to mate. To give an example, P. O. J. 2725 and P. O. J. 2696 flower about the middle of October, while B.6308 and Q. 813 do not arrow till about the middle of November or later ; and the tropical types as a class flower earlier than the indigenous Indian canes.

One sure way of bridging over the flowering interval in time and space is to prolong the viability of pollen. The pollen of various species of plants has been stored alive for quite a long period under (1) definite relative humidities, (2) low temperature, and other suitable conditions. Pfundt [1] kept the pollen of *Pinus sylvestris* alive for 279 days, of *Prunus padus* for 181 days, and of *Digitalis purpurea* for 172 days over H_2SO_4 ; while according to Knowlton [2] the maximum duration of germinative ability of *Antirrhinum* pollen was 670 days, and of fertilizing power 161 days. It is further a matter of common knowledge that the Arabs preserve a few branches of staminate flowers of date for use in the following year.

The pollen of grasses is, in particular, very short-lived. Andronescu [3] working on corn pollen found that the pollen in sealed tubes lived for 24 hours and that in 90 per cent. moisture for 48 hours. Anthony and Harlan[4] found that barley pollen, 24 hours old, produced a greatly decreased percentage of fertilization, while pollen 48 hours old was incapable of effecting fertilization. According to Knowlton [5] corn pollen remained viable longest under conditions of moderately low temperature (5° to 10°C.) and moderately high humidities (50 to 80 per cent.). The maximum

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[1] Pfundt, Max. Der einflus der Luftfenchtigkeit auf die Lebensdauer des Bluthenstaubes. *Jahrb. wiss. Bot.* Vol. XLVII, pp. 1-40, 1910.

[2] Knowlton, H. E. Studies in pollen with special reference to longevity. *Cornell Univ. Agri. Expt. Sta. Mem.* 52, pp. 751-793, 1922.

[3] Andronescu, D. I. The physiology of the pollen of *Zea Mays* with special regard to vitality, pp. 1-36. *Univ. of Illinois* (Unpublished). 1915.

[4] Anthony, S., and Harlan, H. V. Germination of barley pollen. *Jour. Agri. Res.* Vol. XVIII, pp. 525-536. 1920.

[5] *Loc. cit.*

duration of retention of fertilizing power, he states, was from 70 to 80 hours. The preservation of sugarcane pollen received attention from Venkatraman,[1] who designed special crates in which sugarcane arrows could be kept without the anthers protruding out of the flower and thus preventing their dehiscence.

Owing to the importance of preserving the viability of pollen to sugarcane-breeding, experiments were undertaken at the Imperial Sugarcane Station, Coimbatore, in the arrowing season of 1927 to find out the most favourable conditions under which sugarcane pollen would keep viable for a desired length of time. The results obtained are briefly given below :—

(*a*) P. O. J. 2696 pollen kept on 6th November 1927 at 8. A.M. was placed inside a desiccator and the air of the desiccator partially exhausted. The desiccator was kept at a temperature varying from 9° to 13° C. The control on 6th November 1927 gave 560 germinations out of 2,200, with very long pollen tubes. The pollen kept in partial vacuum gave thirty germinations at 8 A.M. on 10th November 1927, *i.e.*, 96 hours after keeping in vacuum.

(*b*) Maur. 131 pollen was kept on 27th November 1927 in corked and paraffined glass tubes at temperatures varying from 9° to 13° C. The control gave 550 germinations out of a total of 2,500 grains. The stored pollen gave 125 germinations on 2nd December 1927, and the pollen tubes were of medium length. With the same pollen, on 4th December, 1927, *i.e.*, 168 hours after keeping in tubes, ten germinations were obtained, but the pollen grains inside the glass tube were found to have adhered together or caked.

The availability of a suitable culture medium [2] for artificially growing sugarcane pollen enabled the testing of pollen viability. It need hardly be pointed out that the capacity to germinate under artificial conditions does not indicate that the same pollen will be capable of fertilizing the ovule, while on the other hand the pollen which fails to germinate artificially has been found to effect fertilization after a long time, suggesting that the fertilizing ability may outlast the power to germinate under artificial conditions. The success, in being able to store alive the sugarcane pollen for seven days, is somewhat of an advance over the storing of corn (Andronescu[3]) and barley (Anthony and Harlan[4]) pollen for three and two days respectively ; but as the aim is to prolong the viability of sugarcane pollen for four weeks or more, the investigation is being continued. [N. L. DUTT.]

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[1] Venkatraman, T. S. Germination and preservation of sugarcane pollen. *Agri. Jour. India*, Vol. XVII, Pt. II, March 1922, pp. 127-132.

[2] Dutt, N. L., and Ayyar, G. G. Germination of sugarcane pollen in artificial culture media. *Agri. Jour. India*, Vol. XXIII, Pt. III, May 1928, pp. 190-202.

[3] *Loc. cit.*

[4] *Loc. cit.*

A NOTE ON GLUTINOUS RICE.

BORA OR BIRAIN (*Oryza Sativa* var. *Glutinosa*).

THERE are a good many varieties of rice familiar to the cultivators of Assam under various names and possessing particular properties which make their cultivation suitable to particular localities. They are generally classified according to the level of the land on which they are grown, the period taken for maturity and the time of harvest. They may be classified as Aus (Autumn rice) Aman (Winter rice) and Boro (Summer rice). The Aman paddy consists of 4 sub-classes, *viz.*, Sail, Aman, Asra and Bora or Birain. Except in Aus, the latter is found in all the other three sub-classes and in Boro. They may be briefly stated as follows :—

Sail Bora. Sail Bora is grown along with Sail on land almost as high as Aus land or somewhat lower. It is always transplanted, sown from June-July, transplanted from July-September and harvested from November-December. The outturn is somewhat less than Sail proper, ranging from 1,600 lb. to 2,000 lb. per acre.

Asra Bora. Asra Bora is grown in Asra land and thrives well in 2 to 5 ft. of water. It is either sown broadcast or transplanted as the opportunity occurs, although the outturn is higher when transplanted. It is sown from March to June, transplanted from May to August and harvested from November-December. The outturn is better than Sail Birain, being from 2,000 lb. to 2,400 lb. per acre.

Aman Bora. Aman Bora is grown well in 5 to 12 ft. of water as in Aman. They are always sown broadcast as the flood water sometimes affects them very badly. It is sown from March to May and harvested from November to December. In most low-lying places sowing takes place even a month earlier. The outturn is from 2,400 lb. to 2,800 lb. per acre.

Boro Bora. The cultivation of Boro Bora is exactly like that of Boro paddy (marsh land paddy). It is grown by the side of the Beels or Haors (large natural depressions) which are left dry by the receding of water in the cold weather. A somewhat higher slope is selected for this class. It is always transplanted and irrigated. It is sown in November, transplanted from December to January and harvested in April and the outturn ranges from 2,400 lb. to 3,200 lb. per acre.

There are various types of Bora in each class. Some with white kernel, some with red, while some are scented and some fine, but most of them are coarse. Bora, when stored for a long time, loses its glutinous quality.

The kernels of Bora paddy are rather soft in texture and when broken show a white opaque appearance. They are very coarse, highly glutinous, and when boiled,

assume a sticky but somewhat repulsive appearance to persons not accustomed to them. They are not taken as ordinary rice but as Indian pastries and pudding. There are 99 varieties of this class of rice in the Assam Valley and 58 in the Surma Valley of Assam.

In cooking this rice, water is kept boiling in an earthen pot and rice is put in another small perforated earthen pot placed on its mouth and then covered with a lid. The rice gets boiled with the steam from below as is generally done in a double boiler. The joint of the two pots is plastered with mud so that no steam can escape by the side. Water is sprinkled at intervals on the pot above. In this way the rice is not over-boiled and is taken with relish either with milk or curd. They are also roasted on fire in green bamboo culms.

In Assam Valley Bora rice is prepared in a special way. Bora dhan is boiled to such an extent that the swelled kernels partly come out of the husk. They are dried on the same day and then husked. This rice, when kept soaked for an hour, will get softened as soaked flat rice (chirā). It is then taken as ordinary boiled rice. The cultivators very often use this rice for their noon meal as they cannot cook their food when working far away from home. Here it seems, it has a commercial possibility. If introduced, it will help the factory or mill labourers in large towns who may take this for their noon meal instead of having a dry lunch. It may also be used in manufacturing starch, cement and glue. Whether this rice can very well be used in bread-making and pastries for hotels is yet open to investigation and research. [S. K. MITRA.]

SUGARCANE SURVEY OF NEW GUINEA BY AEROPLANE.

The United States Department of Agriculture has organized an expedition under the leadership of Dr. E. W. Brandes, who will use an aeroplane in searching the unexplored wilds of New Guinea for disease-resistant cane varieties that may prove useful to the industry in Louisiana and other parts of the south. Dr. Brandes will be accompanied by Dr. Jakob Jeswiet, formerly chief of sugar plant breeding work in Java, now of the University of Wageningen, Holland. They will also be joined by C. E. Pemberton, Entomologist of Hawaiian Sugar Planters' Association Experiment Station, and proceed to Port Moresby, the base of the expedition on the south-east coast of New Guinea. The Aeroplane will be furnished by B. G. Dahlberg, president of the Celotex Co. Equipped with pontoons for landing on rivers, lakes or other bodies of water, it will make possible the exploration of the interior portions of the Island otherwise inaccessible or difficult to reach. The study is expected to take from six to eight months. The Australian Government is co-operating to make the expedition successful. (The *International Sugar Journal*, Vol. XXX, No. 355, July 1928, page 385.)

FACTORS INFLUENCING THE SEVERITY OF THE CRAZY-TOP DISORDER OF COTTON.

The following summary is extracted from *U. S. Department of Agriculture Bull.* 1484 by C. J. King and H. F. Zoomis :—

A new disorder of cotton plants began to attract attention in the Salt River Valley of Arizona in 1919 and became so prevalent in the seasons of 1924 and 1925 as to cause serious financial losses to the cotton growers, on account of the sterility of the plants and the resulting low yields.

Since the first description of the disorder by Cook, in 1923, its occurrence over a wider range of cultural conditions has afforded evidence that the crazy-top injuries are closely associated with unfavourable cultural conditions which produce stress effects in the plants. Although there are symptoms which are distinct from any of the ordinary stress conditions observed in cotton plants in other regions, the extent of injury is so definitely determined by the conditions that cultural methods are indicated as a practical treatment for the disease.

A comparison of areas cropped to cotton for several years with adjoining areas where cotton followed alfalfa showed either a complete absence of the disease or only a few slightly affected plants on the land previously in alfalfa, while the areas cropped continuously to cotton showed a large proportion of affected plants, many of which were seriously deranged.

The recovery of disordered plants when favourable growing conditions were restored and the failure of preliminary attempts to inoculate healthy plants indicate that the disease is of such a character that its development is caused by poor cultural conditions rather than by infection. Although the close relations with stress conditions suggest that the disease may prove to be of a physiological character, careful study should be given to the possible existence of an infective principal whose injurious effects may be in evidence only when the plants undergo stress conditions, although definite injuries may be shown in plants that grow to large size before the end of the season.

The association of the more striking and serious injuries with cemented soils, impervious soil strata, steep grade of land, and areas continuously cropped to cotton for several years would indicate that these factors have some influence on the incidence of the disease as well as on its severity, but do not offer conclusive evidence regarding the nature of the disease.

Fewer diseased plants and milder symptoms were observed on the outside rows and at the lower end of fields with steep gradients than on the inside area, indicating that an increased supply of moisture or a more regularly available supply was a controlling factor in such fields.

Rotation with alfalfa or modified methods of irrigation which bring about deeper penetration of water and a more constant supply of available moisture in the lower root zone would appear to be the most practical measures for controlling the disease.

RELATION BETWEEN WATER AND POTASH IN PLANT PRODUCTION.

The following extract is from the *Jour. of Agr. Res.*, 35, No. 10 :—

INTRODUCTION.

THE beneficial effects of potash fertilizers in dry seasons are mentioned by Hall in his description of the Rothamsted experiments. The relation between potash fertilizers and the economical use of water by crops has also been discussed by Von Seelhorst. Hall considers that plentiful potash prolongs the growth of the plant and offsets the ripening action of the phosphoric acid, which in the absence of potash acts prematurely and the action is intensified by the heat and dryness. The opinion of Von Seelhorst is that the potash effect is in accord with the law of the minimum, and he shows that if nitrogen or phosphorus is the scarce element, its addition will likewise produce a more efficient use of water by the plant.

As part of a study of the availability of the potash naturally present in some typical soils, observations were made on the relations between the water supply and potash supply by means of pot experiments with soy beans and Japanese millet. These two crops are distinctly different types and are admirably suited to growth in pots during the summer.

Wagner pots 25 cm. in diameter and 33 cm. in depth were used in these experiments.

SUMMARY.

Pot experiments were conducted in which Japanese millet and soy beans were grown with varied amounts of potash and of water supplied to the soil, in order to ascertain the relation of the water supply to the availability of the soil potash and the extent to which additions of soluble potash would overcome the lack of water.

Four series of pots were prepared with relation to potash. Series A contained soil that had received no potash fertilizers for 30 years. Series B had potash added to the soil of A. Series C contained soil that had received annual applications of potash fertilizers for 30 years. Series D had potash added to soil of C.

Each series received maximum, medium and minimum supplies of water, based on the water-holding capacity of the soil. The soils with the least water were more like a naturally dry soil than a soil during a drought, because the limited quantities of water were added at short intervals.

The experiments were conducted two seasons. In the first season, the supplies of nitrogen, phosphoric acid and potash were at the rate used in the field from which the soils were obtained. The supplies of these for the second season were much increased as there were indications that the first year's allowance was too small.

Both millet and soy beans on the soil without potash for years gave yields which varied directly as the supplies of water. The percentages of potash in the crops and the quantities by weight indicated that the soil potash had a low solubility and the amount available for crops was dependent on the supply of water.

The millet crops when supplied with available potash were not much affected by lessened supplies of water. The addition of potash increased the production of straw proportionally more than that of seed.

The soy bean crops were affected by both potash and water supply and in about the same proportion. Potash increased seed production proportionally more than the yield of straw. On the soil without potash for years, soy beans were slow to mature, and analysis of the seeds, pods and straw indicated that, with the lack of potash, the nitrogen was not translocated freely from the straw and pods to the seeds.

The plentiful supply of available potash in series B and D in the second season gave an increase in absorption of potash by the crops which was proportionally greater than the increase in plant growth accompanying it.

Available potash with the minimum supply of water enabled millet in the second season to produce 92 gm. of seed and 112 gm. of straw, while without added potash but with abundant water it yielded 75 gm. of seed and 64 gm. of straw. Soy beans under parallel conditions produced 74 gm. of seed with the added potash and 45 gm. without it, but the straw was affected by the water supply.

CONCLUSION.

The natural potash of the soils used in these pot experiments had a low solubility, and both millet and soy beans obtained their supplies of potash from them in direct proportion to the supplies of water. The addition of potash to the other fertilizers increased the concentration of that substance in the soil solution and the millet was then nearly indifferent to the varied amounts of water supplied to it. Soy beans were about equally affected by both potash and water. For testing the availability of potash in a soil, millet appeared to be a better crop than soy beans, because the millet was less affected by variations in the water supply.

The results of the experiment are in accord with the law of the minimum. (Extract taken from the *Journal of Agricultural Research,* Vol. 35, No. 10, November 15, 1927.)

Personal Notes, Appointments and Transfers, Meetings and Conferences, etc.

The head of the Civil Veterinary Department in the Madras Presidency shall in future be styled as "Director of Civil Veterinary Department, Madras".

MR. P. T. SAUNDERS, M.R.C.V.S., Acting Principal, Madras Veterinary College has been granted combined leave for thirteen months from 18th September, 1928.

MR. T. J. HURLEY, M.R.C.V.S., has been appointed to act as Principal, Madras Veterinary College, *vice* Mr. P. T. SAUNDERS granted leave.

MR. H. PETERSON is appointed Agricultural Engineer, Bengal, with effect from 22nd September, 1928.

The notification dated 22nd March, 1928, granting six months' leave to Dr. A. E. PARR, Deputy Director of Agriculture, Western Circle, Aligarh, with effect from 10th April, 1928, or subsequent date is cancelled.

With effect from 15th May to 20th July, 1928, Mr. W. H. COSSAR, Second Agricultural Engineer, officiated as Agricultural Engineer to Government, United Provinces, *vice* Mr. F. H. VICK, retired.

MR. R. BRANFORD, M.R.C.V.S., Live-Stock Officer to Government, Punjab, Hissar, has been granted leave on full average pay for six months and 2 days and in continuation leave on half average pay for one year, 9 months and 28 days, preparatory to retirement, from 15th July, 1928.

MR. J. S. GAREWAL, Superintendent, Civil Veterinary Department, South Punjab, Ferozepore, has been appointed Live-Stock Officer to Government, Punjab, with effect from 28th July, 1928.

MR. L. S. SMITH has been appointed Superintendent, Government Cattle Farm, Hissar, from 1st July, 1928.

The appointment of S. MUBARIK ALI SHAH GILANI, B.SC. (Hons.), M.R.C.V.S., to special temporary post in the Civil Veterinary Department, Punjab, for a period of two years has been extended by a further period of one year with effect from the 30th July, 1928, pending the constitution of the Superior Provincial Service.

The appointment of LALA PRAN NATH NANDA, M.R.C.V.S., to a special temporary post in the Civil Veterinary Department, Punjab, for a period of two years has been extended by a further period of one year with effect from the 30th July, 1928 (forenoon), pending the constitution of the Superior Provincial Service.

The appointment of S. RAM SINGH SARKARIA as Bacteriologist to Government, Punjab, Lyallpur, for a period of two years has been extended by one year with effect from the 30th July, 1928.

On return from leave, Mr. W. M. CLARK, M.B.E., B.Sc., has been posted to Mandalay as Professor of Agriculture, *vice* Mr. H. F. ROBERTSON transferred.

On relief by Mr. W. M. CLARK, M.B.E., Mr. H. F. Robertson, B.Sc., has been posted to the charge of the Northern Circle, Burma, *vice* Mr. T. D. STOCK transferred.

On relief by Mr. H. F. ROBERTSON, Mr. T. D. Stock, B.Sc., has been posted to the charge of the Myingyan Circle, Burma, *vice* U. KYAW ZAN, Assistant Director of Agriculture, proceeding on leave.

On return from leave, Mr. W. GREGSON, N.D.A., has been posted to the charge of the Tenasserim Circle, Burma, *vice* Mr. D. HENDRY.

Mr. D. RHIND, B.SC., Economic Botanist, has been appointed to officiate as Mycologist while continuing to hold the post of Economic Botanist, Burma.

The sixteenth annual meeting of the Indian Science Congress will be held in Madras from January 2nd to January 8th, 1929.

PRESIDENT.

Prof. C. V. Raman, M.A., D.Sc., F.R.S., F.A.S.B., Palit Professor of Physics, Calcutta University.

Sectional Presidents.

1. Agriculture	Mrs. G. L. C. Howard, M.A., Institute of Plant Industry, Indore.
2. Botany	Prof. K. C. Mehta, M.Sc., Ph.D., Agra College, Agra.
3. Medical and Veterinary Research.	Lieut.-Col. R. Knowles, B.A., M.R.C.S., L.R.C.P., I.M.S., F.A.S.B., Professor of Tropical Medicine and Officer in charge, Carmichael Hospital for Tropical Diseases, Calcutta.
4. Mathematics and Physics ..	Prof. S. N. Bose, M.Sc., Prof. of Physics, Dacca University, Dacca.
5. Chemistry	Prof. J. N Mukherjee, M A., D.Sc., Guruprosad Singh Professor of Physical Chemistry, Calcutta University.
6. Anthropology	Lieut.-Col. R. B. Seymour Sewall, M.A., M.R.C.S., L.R.C.P., F.L.S., F.Z.S., I.M.S., F.A.S.B., Director, Zoological Survey of India, Calcutta.
7. Zoology .. .	Lieut.-Col. J. C. Fraser, I.M.S., Principal, Medical College, Vizagapatam.
8. Geology	Dr. Cyril S. Fox, D.Sc., M.I.Min.E., F.G.S., Superintendent, Geological Survey of India, Indian Museum, Calcutta.
9. Psychology	Prof. M. V. Gopalaswami, B.Sc. Ph.D., Professor of Psychology, Maharajah's College, Mysore.

NEW BOOKS

On Agriculture and Allied Subjects

1. The Agricultural Development of Arid and Semi-Arid Regions, with special reference to South Africa, by H. D. Leppan. South Africa, Central News Agency Limited. Price £1-5 nett.
2. The Newer Knowledge of Bacteriology and Immunology, by Eighty-two contributors. Edited by Edwin O. Jordan and I. S. Falk. The University of Chicago Press, Chicago, Illinois.

The following publications have been issued by the Imperial Department of Agriculture in India since our last issue:—

Memoirs.

1. Studies in the Jowars of Gujarat I. The Jowars of the Surat District, by M. L. Patel, M. Ag., and G. B. Patel, B. Ag. (Botanical Series, Vol. XVI, No. 1.) Price, Re. 1-6 or 2*s*. 3*d*.
2. The Indian Cottons, by G. A. Gammie, F.L.S. (Botanical Series, Vol. II, No. 2 ; reprinted.) Price, Rs. 10-2 0.
3. Losses and Gains of Nitrogen in an Indian soil studied in relation to the Seasonal Composition of well waters and the bearing of the results on the alleged deterioration of Soil Fertility, by Harold E. Annett, D.Sc., F.I.C., M.S.E.A.C., and A. R. Padmanabha Aiyer, B.A., and Ram Narayan Kayasth, M.Sc., B.Ag. (Chemical Series, Vol. IX, No. 6). Price, Rs. 2 or 2*s*. 6*d*.
4. Feeding Experiments at Karnal, 1925-26 and 1926-27, by F. J. Warth, M.Sc., and F. J. Gossip. (Chemical Series, Vol. X, No. 1.) Price, As. 8 or 10*d*.

Bulletins.

5. A Study of the Locular Composition in Cambodia Cotton, by V. Ramanathan L.Ag. (Bulletin No. 178.) Price, As. 7 or 9*d*.
6. A Leaf spot and Blight Disease of Onions Caused by *Alternaria palandui*, nov. sp., by C. Rangaswami Ayyangar. (Bulletin No. 179.) Price, As. 6 or 8*d*.
7. Stem-rot of Berseem caused by *Rhizoctonia solani* Kühn, by Md. Taslim. (Bulletin No. 180.) Price, As. 8 or 9*d*.

8. Investigations in the Bacteriology of Silage, 1926-27, by J. H. Walton, M.A., M.Sc. (Bulletin No. 182.) Price, As. 5 or 6*d*.
9. A Milk Fermenting Yeast, by C. S. Ram Ayyar, B.A. (Bulletin No. 183.) Price, As. 5 or 6*d*.
10. List of Publications on Indian Entomology, 1927. Compiled by the Imperial Entomologist. (Bulletin No. 184.) Price, As. 6 or 9*d*.
11. The Composition of Some Indian Feeding Stuffs, by J. N. Sen, M.A., F.C.S. (Bulletin No. 70; reprinted.) Price, Rs. 3-2-0 or 5*s*. 6*d*.

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List of Agricultural Publications in India from 1st February 1928 to 31st July 1928.

No.	Title	Author	Where published
	GENERAL AGRICULTURE.		
1	*The Agricultural Journal of India*, Vol. XXIII, Parts II, III and IV. Price, Re. 1-8 or 2*s.* per part. Annual subscription, Rs. 6 or 9*s.* 6*d.*	Edited by the Agricultural Adviser to the Government of India.	Government of India Central Publication Branch, Calcutta.
2	*The Journal of the Central Bureau for Animal Husbandry and Dairying in India*, Vol. II, Parts 1 and 2. Annual subscription Rs. 2-8, single copy As. 10.	Ditto.	Ditto.
3	Review of Agricultural Operations in India, 1926-27. Price Rs. 2 or 3*s.* 6*d.*	Issued by the Agricultural Adviser to the Government of India.	Ditto.
4	Unit System for Farm Buildings, Pusa Agricultural Research Institute, Bulletin No. 174. Price As. 5 or 6*d.*	G. S. Henderson, N.D.A., N.D.D.	Ditto.
5	Villagers' Calendar for 1928-29 (Tamil, Telegu and Kanarese).	Issued by the Department of Agriculture, Madras.	Government Press, Madras.
6	Note on the Exhibits at the Agricultural Exhibition, IV Circle, comprising North Arcot, South Arcot, Chingleput and Chittoor Districts. Madras Department of Agriculture Leaflet No. 33, revised.	Ditto.	Ditto.
7	Annual Reports of the Experimental Stations, Madras, for 1927-28.	Ditto.	Ditto.
8	Report on the Operations of the Department of Agriculture, Madras, 1927-28, Vol. I.	Ditto.	Ditto.
9	Annual Report of Subordinate officers for 1927-28, Vol. II.	Ditto.	Ditto.
10	The Conduct of Field Experiments. Madras Department of Agriculture Bulletin No. 89.	Ditto.	Ditto.

General Agriculture—contd.

No.	Title	Author	Where published
11	The Manurial Problem and its Solution.	Issued by the Department of Agriculture, Madras.	Government Press, Madras.
12	Year Book 1927 of the Department of Agriculture, Madras.	Ditto.	Ditto.
13	Furnaces for making *gul* or crude sugar in the Bombay Presidency. Bombay Department of Agriculture Bulletin No. 144 of 1927 Price Re 0-7-3.	Rao Bahadur P. C. Patil.	Yeravda Prison Press, Yeravda.
14	Crops of the Bombay Presidency: their Geography and Statistics. Bombay Department of Agriculture Bulletin No. 146 of 1927. Price Re. 1-11-0.	G. R. Ambekar.	Government Central Press, Bombay.
15	Organisation and cost of *Gul* making in the Deccan sugarcane tracts. Bombay Department of Agriculture Bulletin No. 147 of 1927. Price Re. 0-2-6.	Rao Bahadur P. C. Patil.	Yeravda Prison Press, Yeravda.
16	Culture of Guava and its improvement by selection in Western India. Bombay Department of Agriculture Bulletin No. 148 of 1927. Price Re. 0-7-3.	Dr. G. S. Cheema and G. B. Deshmukh.	Ditto.
17	Studies in the cost of production of crops in the Deccan. Bombay Department of Agriculture Bulletin No. 149 of 1927. Price Re. 1-1-6.	Rao Bahadur P. C. Patil, T. G. Shirname and T. B. Pawar.	Ditto.
18	Crops of Sind: their Geography and Statistics. Bombay Department of Agriculture Bulletin No. 150 of 1927. Price Rs. 2-1-0.	G. R. Ambekar.	Government Central Press, Bombay.
19	Water-finder work in the Bombay Presidency. Bombay Department of Agriculture Bulletin No. 152 of 1928. Price Re. 0-8-0.	Rao Bahadur D. L. Sahasrabudhe.	Ditto.
20	Annual Season and Crop Report of the Bombay Presidency for 1926-27. Price Re. 1-11-0.	Issued by the Department of Agriculture, Bombay.	Ditto.
21	Annual Report of the Department of Agriculture in the Bombay Presidency for 1926-27. Price Rs. 2-4-0.	Ditto.	Ditto.

No.	Title	Author	Where published
	General Agriculture—contd.		
22	Monthly and Annual rainfall table in the Province of Bengal for 1927.	Issued by the Department of Agriculture, Bengal.	Sreenath Press, Dacca.
23	Season and Crop Report of Bengal for 1927-28.	Ditto.	Ditto.
24	Improvement of Bengal Cattle. Bengal Department of Agriculture Leaflet No. 1 of 1928.	Ditto.	Ditto.
25	Making a pit silage with unchaffed fodders. Bengal Department of Agriculture Leaflet No. 2 of 1928.	Ditto.	Ditto.
26	Rudiments of Garden Designing .	E. P. Griessen, Deputy Director of Gardens, Saharanpur, U. P.	Government Press, Allahabad.
27	Influence of Parks and Gardens and open space in civic development.	Ditto.	Ditto.
28	Cold Storage of Potatoes . .	P. K. Dey, Plant Pathologist to Government, Cawnpore, U. P.	Ditto.
29	Prospectus of the Punjab Agricultural College, Lyallpur.	Issued by the Department of Agriculture, Punjab	Government Printing, Lahore.
30	Seasonal Notes April (1928) issue.	Ditto.	Ditto.
31	Protecting of Trees from Sunburn. Punjab Department of Agriculture Leaflet No. 51.	Ditto.	Ditto.
32	Hatching chicks. Punjab Department of Agriculture Leaflet No. 56.	Ditto	Ditto.
33	Instructions for working the Lyallpur Automatic Seed Drill. Punjab Department of Agriculture Leaflet No. 57.	Ditto.	Ditto.
34	Candying "*bers*" (*Jujubee*). Punjab Department of Agriculture Leaflet No. 58.	Ditto.	Ditto.
35	Feeding chicks. Punjab Department of Agriculture Leaflet No. 59.	Ditto.	Ditto.
36	Rearing chicks. Punjab Department of Agriculture Leaflet No. 60.	Ditto.	Ditto.

No.	Title	Author	Where published
	General Agriculture—contd.		
37	Annual Report of the Department of Agriculture, Punjab, for 1926-27. Part I.	Issued by the Department of Agriculture, Punjab.	Government Printing, Lahore.
38	A brief outline of the Agricultural conditions in the Punjab.	D. Milne, B.Sc., Director of Agriculture, Punjab.	Ditto.
39	List of Imperial Horse shows to be held during 1928.	Issued by the Department of Agriculture, Punjab.	Ditto.
40	Season and Crop Report of Bihar and Orissa.	Issued by the Department of Agriculture, Bihar and Orissa.	Government Printing, Bihar and Orissa, Gulzarbag.
41	Agricultural Statistics of Bihar and Orissa for 1926-27.	Ditto.	Ditto.
42	Report on the working of the Department of Agriculture of the Central Provinces for 1926-27. Price Re. 1-7-0.	F. J. Plymen, A. C. G. I., Director of Agriculture, Central Provinces.	Government Press, Central Provinces. Nagpur.
43	Report on Demonstration work carried out in the Northern Circle, Central Provinces, together with Reports on Seed and Demonstration Farms for the year 1926-27. Price Rs. 2-4-0.	J. H. Ritchie, M.Sc., Deputy Director of Agriculture, Northern Circle, L. N. Dubey, Offg. Extra Assistant Director, Jabbulpur, and Govind Prasad, Extra Assistant Director, Chhindwara.	Ditto.
44	Report on Demonstration work carried out in the Plateau Sub-Circle, Central Provinces, together with Reports on Seed and Demonstration Farms, Betul and Seoni, for 1926-27. Price Re. 1-8-0.	E. A. H. Churchill, Assistant Director of Agriculture, Chhindwara, and Govind Prasad, Extra Assistant Director, Chhindwara.	Ditto.
45	Report on Demonstration work carried out in the Eastern Circle, Central Provinces, together with the Reports on the Seed and Demonstration Farms at Chandkhuri, Bilaspur and Drug with that of Cattle Breeding Stations attached thereto for 1926-27. Price Rs. 2-14-0.	T. L. Powar, Deputy Director of Agriculture, Eastern Circle, D. R. Moharikar, Extra Assistant Director, Raipur, and N. G. Bhoot, Extra Assistant Director, Drug.	Ditto.
46	Report on Demonstration work carried out in the Western Circle, Central Provinces, together with Reports on the Seed and Demonstration Farms and Cattle Breeding Farms of that Circle for the year 1926-27, Vol. I. Price Re. 1-13-0.	S. G. Mutkekar, Deputy Director of Agriculture, Western Circle, M. S. Barkar, Extra Assistant Director, Akola and S. L. Mohammad, Extra Assistant Director, Amraoti.	Ditto.

No.	Title	Author	Where published
	General Agriculture—contd.		
47	Report on District Demonstration work carried out in the Western Circle, Central Provinces, during the year 1926-27, Vol. II. Price Re. 1-7-0.	S. L. Mohammad, Extra Assistant Director, Amraoti, and M. S. Barkar, Extra Assistant Director, Akola.	Government Press, Central Provinces, Nagpur.
48	Report on the Cattle Breeding Operations in the Central Provinces and Berar for the year 1926-27. Price Re. 1-1-0.	S. T. D. Wallace, Deputy Director of Agriculture in charge Animal Husbandry.	Ditto.
49	Report on the Agricultural College, Nagpur, Chemical, Botanical, Mycological, Entomological Research, Agricultural Engineer's Section, and Maharajbagh, Menagerie, 1925-26. Price Re. 1-5-0.	R. G. Allan, Principal, Agricultural College; A. R. Padmanabha Iyer, Agricultural Chemist; W. Youngman, Economic Botanist for Cotton, C. P. and D. N. Mahta, 2nd Economic Botanist, C. P.; J. F. Dastur, Mycologist to Government, C. P.; J. L. Khare, Assistant Entomologist; R. H. Hill, Officer in Charge of the office of Agricultural Engineer, C. P.; R. G. Allan, Principal, Agricultural College.	Ditto.
50	A Decennial Review of Biochemical Investigations on Soils carried out in the Central Provinces and Berar. Bulletin No. 23 of the Department of Agriculture, Central Provinces. Price As. 5.	D. V. Bal, Bacteriological Assistant, Central Provinces.	Ditto.
51	Scientific feeding of Farm Animals. Bulletin 24 of the Department of Agriculture, Central Provinces. Price As. 8.	R. G. Allan, Principal, Agricultural College, Nagpur.	Ditto.
52	Cultivation of Pine apples. Leaflet No. 1 of 1928 of the Department of Agriculture, Assam.	Issued by the Department of Agriculture, Assam.	Government Press, Shillong.
53	On Guinea Grass. Leaflet No. 2 of 1928 of the Department of Agriculture, Assam (Bengali and Assamese).	Ditto.	Ditto.
54	On Vegetables. Leaflet No. 3 of 1928 of the Department of Agriculture, Assam (Assamese and Bengali).	Ditto.	Ditto.

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55	Fruit culture. Bulletin No. 1 of the Department of Agriculture, Assam (English and Khasi).	Issued by the Government of Agriculture, Assam.	Government Press, Shillong.
56	The *Journal of the Mysore Agricultural and Experimental Union* (Quarterly). Annual Subscription Rs. 3.	Mysore Agricultural Experimental Union.	Bangalore Press, Bangalore.
57	The *Journal of the Madras Agricultural Students' Union* (Monthly). Annual Subscription Rs. 4. Single copy As. 6.	Madras Agricultural Students' Union.	The Electric Printing Works, Coimbatore.
58	The *Planters Chronicle* (Weekly) .	United Planters' Association of South India.	Diocesan Press P. B. 455, Madras.
59	The *Nagpur Agricultural College Magazine* (Quarterly). Annual Subscription Rs. 3.	R. A. Ramayya and R. B. Ekbote, Editors.	Udyama Desha Sevak Press, Nagpur.
60	*Poona Agricultural College Magazine* (Quarterly). Annual Subscription Rs. 2-8-0; Single copy As. 10.	College Magazine Committee, Poona.	Agricultural College, Poona.
61	*The Old Boys' Magazine*, Agricultural College, Cawnpore, (Quarterly). Price As. 8 per copy. Annual Subscription Rs. 2.	M. L. Saksena, L.Ag., Editor.	Cawnpore Printing Press.
62	The *Allahabad Farmer* (Quarterly). Single copy As. 8; per year Rs. 2.	W. B. Hayes, E. W. Jeremy and J. N. Shivpuri.	The Mission Press, Allahabad.
63	The *Bengal Agricultural Journal* (Quarterly). (In English and Bengali). Annual Subscription Re. 1-4-0. Single copy As. 5.	Issued by the Department of Agriculture, Bengal.	Sreenath Press, Dacca.
64	*Quarterly Journal of the Indian Tea Association*, Price As. 6 per copy.	Scientific Department of the Indian Tea Association, Calcutta.	Catholic Orphan Press, Calcutta.
65	*Indian Scientific Agriculturist* (Monthly). Annual Subscription Rs. 4.	H. C. Sturgess, Editor, J. W. Mckay, A.R.C.Sc., N.D.A., Consulting Editor.	Calcutta Chromotype Co., 52-53, Bowbazar Street, Calcutta.
66	*Rural India* (Monthly). Single copy As. 6. Annual Subscription Rs. 3.	A. Swaminatha Ayyar .	President, Forest Panchayet Banking Union, Madras.

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	General Agriculture—concld.		
67	The First issue of the Proceedings and Transactions of the Bengal Agricultural Intelligence Club, Dacca Farm (1923-24). Price for Members Rs. 2 and non-members Rs. 4.	Issued by the Secretary, Bengal Agricultural Intelligence Club, Government Farm, Post Tejgaon, Dacca.	Narayan Machine Press, Dacca.
68	*Kisan*—Agricultural Monthly Magazine started at Indore. Annual Subscription Rs. 3 or Re. 0-5-0 per copy.	Sukhsampattirai Bhandari, M.R.A.S., Editor.	Gajanana Printing Works, Indore.
	AGRICULTURAL CHEMISTRY.		
69	Losses and Gains of Nitrogen in an Indian Soil studied in relation to the seasonal composition of well waters and the bearings of the results on the alleged deterioration of Soil Fertility. Memoirs of the Department of Agriculture in India, Chemical Series, Vol. IX, No. 6. Price Rs. 2 or 3*s*. 6*d*.	Harold E. Annett, D.Sc., F.I.C., M.S.E.A.C., A. Padmanabha Aiyer, B.A., and Ram Narayan Kayasth, M.Sc., B.Ag.	Government of India Central Publication Branch, Calcutta.
70	Some Digestibility Trials on Indian Feeding Stuffs: III. Some Punjab Hays. Memoirs of the Department of Agriculture in India, Chemical Series, Vol. IX, No. 7. Price As. 5 or 6*d*.	P. E. Lander, M.A., D.Sc., A.I.C., and Pandit Lal Chand Dharmani, L.Ag., B.Sc. (Ag.).	Ditto.
71	The Determination of the Electrical conductivity of the Aqueous extract of Soil as a rapid means of detecting its probable fertility. Memoirs of the Department of Agriculture in India, Chemical Series, Vol. IX, No. 8. Price As. 4 or 6*d*.	Ashutosh Sen.	Ditto.
72	Feeding Experiments at Karnal, 1925-26 and 1926-27. Memoirs of the Department of Agriculture in India, Chemical Series, Vol. X, No. 1. Price As. 8 or 10*d*.	F. J. Warth, M.Sc., and F. J. Gossip.	Ditto.
73	A comparative study of the methods of Preparation of the Soil for the Mechanical Analysis with a note on the Pipette Method. Pusa Agricultural Research Institute Bulletin No. 175. Price As. 4 or 5*d*.	Amarnath Puri, M.Sc., Ph.D., and B. M. Amin, B.A.	Ditto.

No.	Title	Author	Where published
	BOTANY.		
74	The Indian Types of *Lathyrus sativus* L. (*khesari, lakh, lang, teora*). Memoirs of the Department of Agriculture in India, Botanical Series, Vol. XV, No. 2. Price Re. 1-8 or 2*s*. 6*d*.	Gabrielle L. C. Howard, M.A. and K. S. Abdur Rahaman Khan.	Government of India Central Publication Branch, Calcutta.
75	Studies on Rice in Sind, Part I. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. XV, No. 6. Price Re. 1 or 1*s*. 9*d*.	K. I. Thadani, M.Sc. and H. P. Durga Dutt, B.Sc.	Ditto.
76	Studies in Gujarat Cottons, Part V. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. XV, No. 7. Price As. 14 or 1*s*. 6*d*.	H. H. Mann, D.Sc., and M. L. Patel, M.Ag.	Ditto.
77	Studies in the Shedding of Mango Flowers and Fruits, Part I. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. XV, No. 8. Price As. 11 or 1*s*. 3*d*.	P. V. Wagle, M.Ag.	Ditto.
78	Studies in the Jowars of Gujarat: I. The Jowars of the Surat District. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. XVI, No. 1. Price Re. 1-6 or 2*s*. 3*d*.	M. L. Patel, M.Ag., and G. B. Patel, B.Ag.	Ditto.
	MYCOLOGY.		
79	Fruit-Rot Diseases of Cultivated Cucurbitaceæ caused by *Pythium aphanidermatum* (Eds.) Fitz. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. XV, No. 3. Price As. 6 or 8*d*.	M. Mitra, M.Sc., F.L.S., and L. S Subramanium, F.L.S.	Government of India Central Publication Branch, Calcutta.
80	*Asteina* spp.	Dr. Ruth Rayan.	Ditto.
	Meliola spp. from India and one from Malay.	Prof. F. L. Stevens.	Ditto.
	Memoirs of the Department of Agriculture in India, Botanical Series, Vol. XV, No. 5. Price As. 4 or 5*d*.		
81	Root-rot and Sclerotial Diseases of Wheat. Pusa Agricultural Research Institute Bulletin No. 177. Price As. 4 or 5*d*.	L. S. Subramanium, F.L.S	Ditto.

No.	Title	Author	Where published
	Mycology—contd.		
82	Stem-rot of Berseem caused by *Rhizoctonia Solani* Kuhn, Pusa Agricultureal Research Institute Bulletin No. 180. Price As. 8 or 9*d*.	Md. Taslim.	Government of India Central Publication Branch, Calcutta.
	ENTOMOLOGY.		
83	Some New Indian Miridæ (Capsidæ). Memoirs of the Department of Agriculture in India, Entomological Series, Vol. X, No. 4. Price As. 6 or 8*d*.	E. Ballard, B.A., F.E.S.	Government of India Central Publication Branch, Calcutta.
84	Studies on *Platyedra gossypiella*, Saunders (Pink Bollworm) in the Punjab. Memoirs of the Department of Agriculture in India, Entomological Series, Vol. X, No. 6. Price, Rs. 1-4 or 2*s*. 3*d*.	Sohan Singh Bindra, M.Sc.	Ditto.
85	A study of the Locular composition in Cambodia Cotton. Pusa Agricultural Research Institute Bulletin No. 178. Price, As. 7 or 9*d*.	V. Ramanathan, L.Ag.	Ditto.
86	List of Publications on Indian Entomology, 1927, Pusa Agricultural Research Institute Bulletin No. 184. Price As. 6 or 9*d*.	Compiled by the Imperial Entomologist, Pusa.	Ditto.
87	Palpicornia. Catalogue of Indian Insects, Part 14. Price Rs. 2-8 or 4*s*. 6*d*.	A. d'Orchymont, F.E.S.	Ditto.
88	Cecidomyidæ. Catalogue of Indian Insects, Part 15. Price As. 7 or 9*d*.	Ronald Senior-White, F.E.S., F. R. S. T. M. & H.	Ditto.
89	Cosmopterygidae. Catalogue of Indian Insects, Part 16. Price, As. 10 or 1*s*.	T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S.	Ditto.
90	Yponomeutidæ. Catalogue of Indian Insects, Part 17. Price As. 8 or 10*d*.	Ditto.	Ditto.
91	The Rice Bug. Madras Department of Agriculture Leaflet No. 50.	Issued by the Department of Agriculture, Madras.	Government Press, Madras.
92	Control of Mound building white ants. Bengal Department of Agriculture Leaflet No. 3 of 1928 (English and Bengali).	Issued by the Department of Agriculture, Bengal.	Sreenath Press, Dacca.

No.	Title.	Author.	Where published.
	BACTERIOLOGY.		
93	A Method of Increasing the Manurial Value of Mahua cake. Pusa Agricultural Research Institute Bulletin No. 176. Price As. 4 or 6*d*.	N. D. Vyas, L.Ag.	Government of India Central Publication Branch, Calcutta.
94	Investigations in the Bacteriology of Silage, 1926-27. Pusa Agricultural Research Institute Bulletin No. 182. Price As. 5 or 6*d*.	J. H. Walton, M.A., M.Sc.	Ditto.
95	A Milk Fermenting Yeast. Pusa Agricultural Research Institute Bulletin No. 183. Price As. 5 or 6*d*.	C. S. Ram Ayyar, B.A.	Ditto.
	VETERINARY.		
96	Trypanblue and certain dithioaniline derivatives: Their efficacy in the treatment of Piroplasmosis and other affections in the Central Provinces. Memoirs of the Department of Agriculture in India, Veterinary Series, Vol. IV, No. III. Price As. 3 or 4*d*.	Major R. F. Stirling, F.R.C.V.S., D.V.S.M., F.Z.S., I.V.S.	Government of India Central Publication Branch, Calcutta.
	Surra	Issued by the Madras Department of Agriculture, Madras.	Government Press, Madras.
97	Report of the work performed by the Camel Specialist, Sohawa, for the year 1926-27. Punjab Department Veterinary Bulletin No. 18.	Issued by the Department of Agriculture, Punjab.	Government Printing, Punjab, Lahore.
98	Annual Report of the Punjab Veterinary College, Civil Veterinary Department, Punjab and the Government Cattle Farm, Hissar, for the year 1926-27.	Ditto.	Ditto.
99	The Annual Administration Report of the Civil Veterinary Department, Ajmer-Merwara, for the year 1927-28.	Issued by the Superintendent, Civil Veterinary Department, Sind and Rajputana.	Government of India Central Publication Branch, Calcutta.

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